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THE

SIDEREAL HEAVEN

AND

OTHER SUBJECTS CONNECTED WITH

ASTRONOMY,

AS ILLUSTRATIVE OF THE CHARACTER OF THE DEITY, AND OF AN INFINITY OF WORLDS.

"The worlds were framed by the word of God."—PAUL.

BY THOMAS DICK, LL.D.,

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PREFACE.

The favourable reception which the volume entitled "CELESTIAL SCENERY" has met with from the public, both in Britain and America, has induced the author to extend his survey to other sublime scenes connected with the science of astronomy. The chief object of the work alluded to was to illustrate, more fully than had previously been attempted, the scenes connected with the planetary system. In the present volume, the author has directed the attention of his readers to scenery of a still more elevated and sublime description, connected with the "Sidereal Heavens." All the facts related to this subject, which can be considered as interesting to general readers, have been particularly detailed, and in such a manner as to be generally comprehensible by those who have little knowledge of mathematical science or the more abstruse parts of astronomy.

In describing such sublime scenes as are here unfolded, the author, as on former occasions, has freely indulged in such remarks and moral reflections as were naturally suggested by the grandeur of his

subject: and has endeavoured to lead the minds of his readers to the contemplation of the attributes and the agency of that Almighty Being, by whom the vast system of universal nature was at first brought into existence, and by whose superintending care it is incessantly conducted in all its movements.

The subject of a plurality of worlds has been resumed, and additional arguments, both from reason and revelation, have been brought forward so as to exhibit this position, not merely as conjectural or highly probable, but as susceptible of moral demonstration. For the gratification of amateur observers possessed of telescopes, particular descriptions have been given of the *positions* of some of the more remarkable phenomena in the sidereal heavens, that they may be induced to contemplate them with their own eyes. For a similar reason, the author has described the various aspects of the heavens throughout the year, and the positions of the planets for 1840 and 1841. As the subject of *comets* was unavoidably omitted in the preceding volume, the author has condensed, in the concluding chapter, the greater part of the facts which have been ascertained respecting the nature, phenomena, and influence of those anomalous bodies.

It was originally intended, had the limits of the present volume permitted, to direct the attention of

the student to other objects related to the scenery of the heavens, and to the construction and application of some of those instruments which are devoted to celestial observations. Should the work now published meet with a favourable reception, the author intends, in a smaller volume than the present, to elucidate some of the subjects to which he alludes, especially the following: the construction and use of optical instruments, particularly the reflecting and achromatic telescope, and the equatorial. As the author has performed a great variety of experiments in relation to such instruments, he hopes to have it in his power to suggest some new and useful hints in reference to their construction and improvement. The doctrine of eclipses and occultations; the precession of the equinoxes, &c.; the construction of observatories, and the manner of using astronomical instruments; the *desiderata* in astronomy, and the means by which the progress of the science may be promoted; the practical utility, physical and moral, of astronomical studies; their connexion with religion, and the views they unfold of the attributes and the empire of the Creator, with several other correlative topics, will likewise be the subject of consideration. The whole to be illustrated with appropriate engravings, many of which will be original.

Broughty Ferry, near Dundee,
January 24, 1840.

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Page 71, line 15 from top, *for* "tenacity" *read* "tenuity."

THE

SIDEREAL HEAVENS.

INTRODUCTION.

In a work lately published under the title of "Celestial Scenery,"* I endeavoured to exhibit a pretty full display of all the prominent facts connected with the motions, distances, magnitudes, and other phenomena of the planets, both primary and secondary, and of the observations and reasonings by which they are supported. These bodies, forming a part of the solar system to which we belong, and lying within the limits of measurable distance, can be more distinctly surveyed, and their magnitudes and other phenomena more accurately investigated, than those of the remoter orbs of the firmament. Hence, in consequence of the accurate observations of modern times, we can now speak with a degree of certainty and precision respecting their order and arrangement, their periodical revolutions, their distances from the sphere we occupy and from the centre of the system, their real bulk, the appearance of their surfaces, and the objects which diversify their respective firmaments. But when we pass the boundary of the planetary system, and attempt to explore the orbs which lie beyond it, we have to travel, as it were, through dark and pathless regions; we have to traverse an immense interval, which has hitherto baffled all the efforts of human science and ingenuity to determine its extent. The fixed stars lie completely beyond the dominions of the sun; they feel not his attractive influence; they revolve not around him as a centre, nor are they enlightened by his effulgence. It follows that our knowledge of those remote luminaries must be extremely

* No. 89 of Harpers' Family Library.

imperfect, and our views of the distant regions in which they are placed comparatively limited and obscure.

But notwithstanding the immeasurable distance of the starry regions, and the limited nature of human vision, we are not altogether ignorant of those remote and unexplored dominions of Omnipotence, or of the magnitude and splendour of the bodies they contain. The telescope has enabled us to penetrate the vast spaces of the universe, and has opened a *vista* through which thousands of suns and systems are distinctly beheld, which would otherwise have been for ever veiled from the view of mortals. It has extended the boundaries of our vision thousands of times beyond its natural limits, and collected the scattered rays of light from numerous distant orbs, which, without its assistance, would never have entered our eyes. It has served the purpose of a celestial vehicle to carry us towards the heavens, and has produced the same effect on our visual powers as if we had been actually transported thousands of millions of miles nearer the unexplored territories of creation. Guided by this noble instrument, scenes and objects have been disclosed to view of which former generations could form no conception, and which lead the reflecting mind to the most elevated views of the perfections of the Deity, and to the most expansive prospects of the grandeur and magnificence of his empire.

For a considerable period after the true system of the world was recognised, astronomers were disposed to consider the stars as so many insulated luminaries, scattered almost at random throughout the vast spaces of the universe. Having engaged in no very *extensive* surveys of the celestial vault, and resting contented with the idea that the stars were so many suns, dispersed in a kind of magnificent confusion throughout the immensity of space, they seemed to have formed no conception of any specific difference in the nature of these bodies, or of any systematic arrangement as existing among them. Hence it happened that no discoveries of importance were made in the region of the stars, from the time of Huygens and Cassini till near the latter part of the eighteenth century; so that a whole century elapsed without materially enlarging our views of the sidereal heavens, and of the variety, order, and arrangement of the numerous bodies which every portion of those expansive regions presents to view. During the last sixty or seventy years, the attention of astronomers has been

more particularly directed to sidereal observations; and among those who have laboured with success in this department of astronomical investigation, the late Sir William Herschel stands pre-eminent. Fired with a noble zeal for the improvement of his favourite science, and for the enlargement of his views of the distant regions of creation, he set to work with enthusiastic ardour, and constructed with his own hands telescopes of a size and magnifying power far superior to what had ever before been attempted. Mounted on the top of his forty-feet reflecting telescope, he not only discovered new bodies within the limits of the planetary system, but brought to light innumerable phenomena in regions of the firmament where the eye of man had never before dared to penetrate. He explored the Milky-way throughout all its profundities, and found that whitish zone of the heavens to consist of a multitude of stars "which no man could number," fifty thousand of them having sometimes passed through the field of his telescope in the space of an hour. During the coldness and profound silence of many sleepless nights, he surveyed almost every portion of the celestial concave, and discovered more than two thousand *nebulæ*, or starry systems, of various forms and descriptions, along with multitudes of double, triple, and quadruple stars which had formerly been unknown, and ascertained, from the change of their relative positions, some of their real motions and periods of revolution. After more than half a century spent in unwearied observations of the heavens, this illustrious astronomer departed from this earthly scene in 1822, without infirmities and without pain, in the eighty-fourth year of his age, leaving a son to prosecute his labours endued with virtues and talents worthy of his father, and whose observations and researches have already enriched the science of astronomy, and extended our views of the sidereal system.

This department of astronomical science may be considered as still in its infancy. Years, and even centuries, must roll on, and the number of astronomical observers must be increased a hundred fold, before the sidereal investigations now going forward can be nearly completed. A more extensive knowledge of the history of the heavens, of the bodies which lie hidden in the yet unexplored region of space, and of the changes and diversified motions to which they are subject, is doubtless reserved for generations to come; and from the at-

tention which has lately been paid to this subject, and the ardour with which it is now prosecuted in different parts of the world, we have reason to expect that new scenes of divine wisdom and omnipotence will be gradually unfolding, and new and interestin gresults deduced from the nocturnal labours of those who have devoted themselves to celestial investigations. To what extent our knowledge of the objects of this science may yet reach, it is impossible for us to anticipate. The objects in the heavens present a scene which is absolutely boundless; which all the generations of men that may arise till the termination of our terrestrial system will never be able fully to explore; a scene which will doubtless engage the study and contemplation of numerous orders of intellectual beings throughout all the revolutions of eternity.

In the following work I propose to give only a very condensed view of the leading objects which have been lately discovered in the sidereal heavens. The facts in relation to this subject will be selected chiefly from the observations of Sir W. Herschel and several other astronomers, and some of them from personal observation. Most of the facts to which I allude were ascertained by Sir W. Herschel by means of telescopes of great size and power, and a considerable number of the double and triple stars, stellar and planetary nebulæ, and other phenomena, cannot be perceived with instruments of an ordinary size. Certain interesting facts, too, particularly with regard to the motions of double stars, have lately been brought to light by the observations of Sir John Herschel, made in the southern hemisphere; but the bodies to which I allude cannot be seen in the northern latitudes in which we reside. A considerable portion, therefore, of our information on this subject must necessarily depend on the observations of the astronomers to whom I allude, and the statements they have published to the world; but these observations have, for the most part, been abundantly verified by other observers.

It shall be our endeavour to state the prominent facts connected with the sidereal heavens in as plain and perspicuous a manner as possible; and while it forms no part of our plan to frame hypotheses, or launch out into theoretical disquisitions, we shall offer those remarks, and freely indulge in these moral reflections, which the contemplation of such august objects are calculated to suggest. The scenes we intend

to exhibit are not only the workmanship of God, but display the glory of his attributes and the magnificence of his empire in a degree, and upon a scale, far surpassing what can be seen in any other department of creation; and therefore, in all our surveys of those grand and multifarious objects, we ought invariably to connect our views and investigations with the supreme agency of Him who brought them into existence, and to cherish those sentiments and emotions which may inspire us with reverence and adoration of that glorious and incomprehensible Being "by whom the worlds were framed," "who created all things, and for whose pleasure they are and were created."

CHAPTER I.

A GENERAL VIEW OF THE STARRY HEAVENS, WITH REPRESENTATIONS OF DETACHED PORTIONS OF THE FIRMAMENT.

If we could suppose a community of rational beings to have lived for ages in some subterraneous grottoes far beneath the surface of the earth, and never to have visited the exterior portions of our globe, their ideas must have been extremely circumscribed, and their enjoyments extremely imperfect, even although they had been furnished with everything requisite for their animal subsistence. Could we imagine that such beings were all at once transported to the surface of the earth, with what astonishment and wonder would they be seized when they beheld the expansive landscape of the world; the lofty mountains towering to the clouds; the hills crowned with magnificent forests; the plains stretching to the boundaries of the horizon, and adorned with colours of every shade; the expansive lake, like a magnificent mirror, imbosomed among the hills; the rivers rolling their watery treasures towards the ocean; and the sun in the firmament revolving around the circuit of the sky, diffusing his light and heat on every surrounding object! Above all, with what emotions of admiration would they be filled when they beheld the solar globe descending below the western horizon, and soon after

the moon displaying her silver crescent in the sky, and the stars, one after another, emerging from the blue ethereal, till the whole celestial concave appeared all over spangled with a thousand shining orbs, emitting their radiance from every part of the cope of heaven, and all moving, with an apparently slow and silent motion, along the spaces of the firmament! Such expansive and novel scenes would undoubtedly overwhelm the faculties of such beings with astonishment, and transport, and wonder inexpressible.

We are placed, perhaps, in a situation nearly similar in regard to the remote regions of the universe, as the beings we have supposed were situated with respect to the ample prospects we enjoy on the surface of our globe. Were such beings, from their subterranean abodes, to look through a narrow funnel which presented them with a feeble glimpse of our upper world and of a portion of the sky, the view thus obtained would somewhat resemble the partial glimpse we have yet acquired of the splendour and sublimities of the distant universe; and were we transported to those far distant scenes, which appear through our telescopes only like dim specks of light, we should doubtless be as much overpowered with astonishment and wonder at the magnificent scenes which would open to our view, as our supposed subterraneous inhabitants could be at the amplitude and grandeur of our terrestrial abode.

In our present habitation we are confined to a mere point in the infinity of space. Ample as our prospects are, it is not improbable that the views we have already attained bear a less proportion to the whole immensity of creation than the limited range of a microscopic animalcule bears to the wide expanse of the ocean. What is seen by human eyes, even when assisted by the most powerful instruments, may be as nothing when compared to what is unseen, and placed for ever beyond the view of mortals. Since the heavens first began to be contemplated, our views have been carried thousands of times farther into the regions of space than the unassisted eye could enable us to penetrate; and at every stage of improvement in optical instruments our prospects have been still farther extended, new objects and new regions o creation have appeared rising to our view, in boundless perspective, in every direction, without the least indication of a boundary to the operations of Omnipotence; leaving us no

room to doubt that all we have hitherto discovered is but a small and inconsiderable part of the length and breadth, and the height and depth of *immensity*. We may suppose, without the least degree of improbability or extravagance, that, were the whole of the *visible* system of creation annihilated, though it would leave a void immeasurable and incomprehensible by mortals, it would appear to the eye of Omniscience only as an inconsiderable blank, scarcely discernible amid the wonders of wisdom and omnipotence with which it is surrounded.

Such views and deductions have been derived from attentive surveys of the STARRY HEAVENS. These heavens present, even to the untutored observer, a sublime and elevating spectacle. He beholds an immense concave hemisphere, surrounding the earth in every region, and resting, as it were, upon the circle of the horizon. Wherever he roams abroad, on the surface of the land or of the ocean, this celestial vault still appears encompassing the world; and after travelling thousands of miles, it seems to make no nearer an approach than when the journey commenced. From every quarter of this mighty arch numerous lights are displayed, moving onward in solemn silence, and calculated to inspire admiration and awe. Even the rudest savages have been struck with admiration at the view of the nocturnal heavens, and have regarded the celestial luminaries either as the residences of their gods or the arbiters of their future destinies.

But to minds enlightened with the discoveries of science and revelation the firmament presents a scene incomparably more magnificent and august. Its concave rises towards immensity, and stretches, on every hand, to regions immeasurable by any finite intelligence; it opens to the view a glimpse of orbs of inconceivable magnitude and grandeur, and arranged in multitudes which no man can number, which have diffused their radiance on the earth during hundreds of generations; it opens a vista which carries our views into the regions of *infinity*, and exhibits a sensible display of the *immensity* of space and of the boundless operations of Omnipotence; it demonstrates the existence of an eternal and incomprehensible Divinity, who presides in all the grandeur of his attributes over an unlimited empire; it overwhelms the contemplative mind with a display of the riches of his wisdom and the glories of his OMNIPOTENCE; it directs our prospects

to the regions of other worlds, where ten thousand times ten thousands of intelligences, of various orders, experience the effects of divine love and beneficence. Amid the silence and the solitude of the midnight scene, it inspires the soul with a solemn awe and with reverential emotions; it excites admiration, astonishment, and wonder in every reflecting mind, and has a tendency to enkindle the fire of devotion, and to raise the affections to that ineffable Being who presides in high authority over all its movements. While contemplating, with the eye of intelligence, this immeasurable expanse, it teaches us the littleness of man, and of all that earthly pomp and splendour of which he is so proud; it shows us that this world, with all its furniture and decorations, is but an almost invisible speck on the great map of the universe; and that our thoughts and affections ought to soar above all its sinful pursuits and its transitory enjoyments. In short, in this universal temple, hung with innumerable lights, we behold, with the eye of imagination, unnumbered legions of bright intelligences, unseen by mortal eyes, celebrating, in ecstatic strains, the perfections of Him who is the creator and governor of all worlds; we are carried forward to an eternity to come, amid whose scenes and revolutions alone the magnificent objects it contains can be contemplated in all their extent and grandeur.

It is an evidence of the depraved and grovelling dispositions of man that the firmament is so seldom contemplated with the eye of reason and devotion. No other studies can present an assemblage of objects so wonderful and sublime; and yet, of all the departments of knowledge which are generally prosecuted, no one is so little understood or appreciated by the bulk of mankind as tho science of the heavens. Were it more generally studied, or its objects more frequently contemplated, it would have a tendency to purify and elevate the soul, to expand and ennoble the intellectual faculty, and to supply interesting topics for conversation and reflection. The objects in the heavens are so grand, so numerous, so diversified, and so magnificent, both in their size and in the rapidity of their motions, that there appears no end to speculation, to inquiry, to conjecture, to incessant admiration. There is ample room for all the faculties of the brightest genius to be employed, and to expatiate in all their energy on this boundless theme; and were they thus employed more frequently than they are, our views of the arrangement and the nature

of the magnificent globes of heaven might be rendered still more definite and expansive.

While contemplating the expanse of the starry heavens, the mind is naturally led into a boundless train of speculations and inquiries. Where do these mighty heavens begin, and where do they end? Can imagination fathom their depth, or human calculations and figures express their extent? Have angels or archangels ever winged their flight across the boundaries of the firmament? Can the highest created beings measure the dimensions of those heavens, or explore them throughout all their departments? Is there a boundary to creation beyond which the energies of Omnipotence are unknown, or does it extend throughout the infinity of space? Is the immense fabric of the universe yet completed, or is almighty power still operating throughout the boundless dimensions of space, and new creations still starting into existence? At what period in duration did this mighty fabric commence, and when will it be completed? Will a period ever arrive when the operations of creating power shall cease, or will they be continued throughout all the revolutions of eternity? What various orders of intellectual beings people the vast regions of the universe? With what mental energies and corporeal powers are they endowed? Are they confined to one region of space, or are they invested with powers of locomotion, which enable them to wing their flight from world to world? Are they making rapid advances, from age to age, in intellectual improvement? Has moral evil ever made inroads into those remote regions of creation, or are all their inhabitants confirmed in a state of innocence and bliss? Is their history diversified by new and wonderful events, and do changes and revolutions happen among them? Are all the tribes of intellectual natures throughout creation connected together by certain relations and bonds of union, and will a period ever arrive in the future revolutions of eternity when they shall have had an intimate correspondence with one another? These, and hundreds of similar inquiries, are naturally suggested by serious contemplations of the objects connected with the starry heavens, and they have a tendency to lead the mind to sublime and interesting trains of thought and reflection, and to afford scope for the noblest energies of the human soul.

But leaving such reflections, in the mean time, let us now

take a general view of the starry heavens as they appear to the eye of a common spectator.

When an untutored observer attempts to take a serious survey of the starry firmament for the first time, he is apt to be bewildered at the idea of the immense multitude of stars which seem to present themselves in every part of the sky, and the apparent confusion with which they seem to be arranged. He is apt to think that they are absolutely innumerable, and that all attempts to enumerate or to classify them would be in vain. There is something so magnificent and overpowering in a cursory view of a clear starry sky, that the mind shrinks from the idea of ever being able to form a distinct conception of the number and order of those luminous orbs, or of their distances and magnitudes; but the genius and industry of man have, in numerous instances, accomplished what at first view appeared beyond the reach of the human faculties. All the stars *visible to the naked eye* have been numbered, and their relative positions determined, with as much precision as the longitudes, latitudes, and bearings of places on the surface of the globe; and there is not a star visible to the unassisted eye, but its precise position can be pointed out, not only during the shades of night, but even during the day, when the sun is shining in all his splendour.

In order to prevent confusion in our first surveys of the starry heavens, let us fix upon a certain portion of the firmament, and the more conspicuous stars which lie in its immediate vicinity. Let us suppose ourselves contemplating the heavens about the middle of January, at eight o'clock in the evening, in the latitude of 52° north. At that time, if we turn our faces towards the south, we shall behold the splendid constellation of *Orion* a little to the east of the meridian, or nearly approaching the south. This constellation forms one of the most striking and beautiful clusters of stars in the heavens, and is generally recognised even by common observers. It is distinguished by four brilliant stars in the form of an oblong or parallelogram; and particularly by three bright stars in a straight line near the middle of the square, or parallelogram, which are known by the names of "the Three Kings," or the "Ell," or "Yard." They are also termed Orion's *belt*; and in the book of Job, "the *bands* of Orion;" and the space they occupy is exactly three degrees in length. The line passing through these three stars points to the *Pleiades*,

or seven stars, on the one side, and to *Sirius*, or the Dog Star, on the other. The equinoctial circle passes through the uppermost of these stars, which is called *Mintika*. They are situated about eight degrees west from the *solstitial colure*, or that great circle which passes through the poles of the heavens, and the first points of Cancer and Capricorn, in which the sun is in his greatest declination north and south, which happens on the 21st of June and 21st of December. There is a row of small stars which run down obliquely below the belt, and seem to hang from it, which is denominated the *sword* of Orion. About the middle of this row of stars there is perceived, by means of the telescope, one of the most remarkable *nebulæ* in the heavens. The whole number of stars visible by the naked eye in this constellation has been reckoned at about 78; of which two are of the first magnitude, namely, *Rigel*, in the left foot on the west, and *Betelguese*, on the east shoulder. They are connected by a line drawn through the uppermost star of the belt. There are four stars of the second magnitude, three of the third, and fifteen of the fourth; but several thousands of stars have been perceived by good telescopes within the limits of this constellation.

North by west of Orion is the constellation *Taurus*, or the Bull, one of the signs of the zodiac. The *Pleiades*, or the seven stars, so frequently alluded to both in ancient and modern times, form a portion of this constellation. At the time now supposed, they are a very little beyond the meridian to the west, and about thirty-seven degrees north by west of the belt of Orion, at an elevation above the horizon of about sixty-four degrees. This cluster was described by the ancients as consisting of seven stars, but at present only six can be distinguished by the naked eye. With powerful telescopes, however, more than 200 stars have been counted within the limits of this group. The *Hyades* is another cluster, situated about eleven degrees southeast from the Pleiades, consisting chiefly of small stars, so arranged as to form a figure somewhat like the letter V. On the left, at the top of the letter, is a star of the first magnitude, named *Aldebaran*, or the Bull's Eye, which is distinguished from most of the other stars by its *ruddy* appearance. This constellation is situated between *Perseus* and *Auriga* on the north, and has *Gemini* on the east, *Aries* on the west, and *Orion* and *Eridanus* on the south. It consists of about 140 stars visible to the naked eye.

The constellation *Gemini* is situated northeast from Orion, and almost due east from the Pleiades, and is one of the signs of the zodiac. It has *Cancer* on the east, *Taurus* on the west, and the *Lynx* on the north. The orbit of the earth, or the apparent circle described by the sun in his annual course, passes through the middle of this constellation. From the 21st of June till the 23d of July, the sun passes through this sign, but the stars of which it is composed are then invisible, being overpowered by the superior brightness of the solar rays. This constellation is easily distinguished by two brilliant stars, denominated *Castor* and *Pollux*, which are within five degrees of each other. *Castor*, a star of the first magnitude, is the northernmost of the two; and *Pollux*, a star of the second magnitude, is situated a little to the southeast of it. Castor is found by the telescope to be a double star, the smaller one being invisible to the naked eye; and, from a long series of observations, it is found that the smaller star is revolving around the larger with a slow motion, and that a complete revolution will occupy more than 300 years. About twenty degrees southwest of Castor and Pollux are three small stars, nearly in a stright line, and about three or four degrees distant from each other. The southernmost of the three lies nearly in a line with Pollux and the star *Betelguese*, in the constellation of Orion, but somewhat nearer to Betelguese than to Pollux. These stars, in the hieroglyphic figure of Gemini, form the feet of the twins.

Directly south of Gemini is the constellation of *Canis Minor*, or the Lesser Dog. It is situated about midway between Gemini and *Canis Major*, or the Greater Dog, and has *Hydra* on the east and Orion on the west. It consists of only fourteen stars visible to the naked eye, the principal of which is *Procyon*, a bright star between the first and second magnitude. It is almost directly south from Pollux, and distant from it about twenty-four degrees. The next brightest star in this constellation, which is considerably smaller than Procyon, is called *Gomelza*, and is situated about four degrees northwest of Procyon.

South by west of Canis Minor, at the distance of nearly thirty degrees, is *Canis Major*, or the Greater Dog. It is southeast from the belt of Orion, and due east from the constellation of *Lepus*, or the Hare, at the distance of ten degrees. Canis Major is easily distinguished by the brilliancy

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of its principal star *Sirius*, which is apparently the largest and brightest fixed star in the heavens, so that it is generally considered as one of the nearest of these distant orbs, though its distance from the earth is computed at not less than *twenty billions* of miles; and a cannon ball, moving over this immense space at the rate of nineteen miles a minute, would require more than two millions of years before it could reach this distant orb. Sirius is south by east of Betelguese in the left shoulder of Orion, at the distance of twenty-seven degrees, and southeast from the lower star in the belt, at the distance of twenty-three degrees. A line drawn through the three stars which form the belt, towards the southeast, leads the eye directly to Sirius, which, at the period and hour we have stated, is about twelve degrees above the southeasterly point of the horizon; a line drawn from Betelguese southeast towards Sirius, and thence to the northeast, meets Procyon in Canis Minor, and, continued nearly due west, it again meets Betelguese, so that these three stars seem to form a large triangle, which is nearly equilateral. Another triangle is formed by drawing a line eastward from Betelguese to Procyon, as a base, from Procyon straight north to Pollux, and from thence again southwest to Betelguese, which forms a right-angled triangle, having the right angle at the star Procyon, and the line extending from Pollux to Betelguese forms the hypothenuse.

In order to render these descriptions more definite, I have sketched in Plate I. a small map of this portion of the heavens, in which the principal stars in the constellations above described are represented. The *left*-hand side of this map represents the *east;* the *right*-hand side the *west;* the lower part the south; and the upper part the north, or higher portion of the heavens. When used so as to compare it with the real firmament, the observer is supposed to have his face directed chiefly to the south and the southeastern parts of the sky. He may then easily distinguish the principal stars laid down in it by the following directions: A line drawn from *A* to *B*, at the top of the map, passes through the star *Castor* in Gemini, which is near the left-hand side. A line drawn from *C* to *D* passes through *Pollux*, in the same sign, which is four or five degrees to the southeast of Castor; it likewise passes near *Auriga*, a star of the second magnitude, in the constellation of the *Wagoner*, which is represented near the middle of the line. Almost directly north from Auriga, at the dis-

tance of seventeen degrees, is the star *Capella*, in the same constellation, which is one of the brightest stars in the heavens next to Sirius. It is about twenty-eight degrees northeast from the Pleiades, but is beyond the northern limits of the map. A line drawn from *E* to *F* passes through *Aldebaran*, or the Bull's Eye, and the Hyades; northwest of which is the Pleiades, or seven stars, near the northwest part of the map. A line drawn from *G* to *H* passes through the star *Betelguese*, in the east shoulder of Orion; the line from *I* to *K* passes through *Bellatrix*, in the west shoulder, a star of the second magnitude, somewhat less brilliant than Betelguese, and likewise passes through *Procyon*, in Canis Minor, which appears near the left side of the map; and the line from *L* to *M* passes through the middle star of Orion's belt. The line from *N* to *O* passes through *Rigel*, in the left foot of Orion, a star of the first magnitude, fifteen degrees south of Bellatrix. The line *P Q* passes through *Saiph*, a star of the third magnitude, in Orion's right knee, eight and a-half degrees east of Rigel. These two form the lower end of the parallelogram of Orion. The line *R S* passes through the star *Sirius*, in Canis Major, which is east by south from Saiph, at the distance of fifteen degrees. The small stars to the west, or right hand of Sirius, form a part of the constellation of *Lepus*, or the Hare. A line drawn from *T* to *U*, from the northern to the southern part of the map, will point out the position of the stars here represented with respect to the meridian, at the time these observations are supposed to be made. The stars on the right of this line are west of the meridian, and all those to the left are to the east of it.

By attending to the above directions, and comparing the delineations on the map with the heavens, all the stars and constellations noted above may be readily distinguished. The triangles formed by Betelguese, Procyon, and Sirius, and by Pollux, Procyon, and Betelguese, will likewise be seen on the map, as formerly described, and may be easily traced in the heavens. Although I have fixed on the middle of January, at eight o'clock in the evening, for these observations, yet the same stars may be traced, at different hours, during the months of November, December, January, February, and March. About the middle of November, at midnight, and the middle of December, at ten o'clock P.M., this portion of the heavens will appear nearly in the same position as here

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represented. About the middle of February, Orion will be on the meridian about eight in the evening; and in the month of March, at the same hour, considerably to the west of it; but all the adjacent stars and constellations may be traced at this time in the manner already described. The stars and constellations delineated on this map comprehend a space in the heavens extending in breadth, from north to south, about fifty degrees; namely, from thirty-three degrees of north declination to seventeen degrees south; and in length, from west to east, about sixty degrees. The *equator* runs through this portion of the heavens in the direction *a b*, or nearly corresponding to the line *L M*, so that it passes very near to the upper star in the belt of Orion. The degrees of north and south declination* from the equator are marked on the margin.

Plate II. represents another portion of the heavens as it appears about the beginning of September. It includes some of the larger stars belonging to the constellations *Cygnus*, *Lyra*, *Cerberus*, *Serpentarius*, *Aquila*, *Hercules*, and *Corona Borealis*. At ten o'clock in the evening of the 1st of September, the star Altair, in the constellation of Aquila, or the Eagle, will be nearly on the meridian, at an elevation above the horizon of about forty-six degrees. This star, which is between the first and second magnitude, is situated near the east or left-hand side of the map, near the bottom, and has a small star to the south, and another to the northwest of it. A line drawn from *T* to *U* passes through the star Altair, and a line from *V* to *W* passes through the meridian, at the hour supposed.

The seven stars which are nearest Altair, towards the south, and west, and northwest, belong to the constellation of *Aquila*. All the stars on the map which are to the right hand of Altair are *west* of the meridian. A line drawn from *X* to *Y*, near the top of the map, passes through *Deneb*, a bright star of the second magnitude in the constellation of *Cygnus*, or the Swan, which is the star next the left-hand

* The *declination* of a heavenly body is its distance north or south from the equinoctial or equator, and corresponds to *latitude* on the terraqueous globe, which is the distance of a place from the equator. The latitude of a *heavenly body* is its distance north or south of the *ecliptic*, or apparent path of the sun, which forms an angle of 23 1-2 degrees with the equinoctial.

side, nearly due north from Altair, at the distance of thirty-six degrees; the other four stars adjacent to it belong to the same constellation. A line drawn from *A* to *B* passes through the star *Vega*, or *a Lyra*, a brilliant star of the first magnitude in the constellation of the *Harp*. The six small stars to the southeast of it likewise belong to this constellation. The stars on the right, or to the westward of Vega, belong chiefly to the constellation of *Hercules*. A line drawn from *C* to *D* passes through the principal star of *Corona Borealis*, or the Northern Crown, named *Alphacca*, which is of the third magnitude, and near the right-hand side of the map. The stars north and east from it belong to the same constellation. West from Alphacca is *Mirac*, at the distance of eleven degrees; and southwest of Mirac, at the distance of ten degrees, is *Arcturus*, a bright star of the first magnitude, which is then about eighteen degrees above the western horizon. Both these stars are in the constellation *Bootes*, but they are not within the limits of the map. A line drawn from *F* to *G* passes through *Ras Algethi*, a star of the second magnitude, and the principal star in the constellation of *Hercules*, which is twenty-five degrees southeast of Corona Borealis. A line from *H* to *I* passes through *Ras Alhague*, a star of the second magnitude in the head of *Serpentarius*. This star is five degrees east by south, of Ras Algethi. Most of the other stars to the south and east in the map belong to Serpentarius. Various other remarkable stars may be seen at this time besides those noted in the map, particularly the square of *Pegasus*, or the Flying Horse. About fifty-three degrees nearly east from Altair is *Markab*, a star of the second magnitude; sixteen and a half degrees east of Markab is *Algenib*, another star of the second magnitude; fourteen degrees north of Algenib is *Alpheratz*, and fourteen degrees west of Alpheratz is *Scheat*, both of them stars of the second magnitude. These four stars, of nearly equal magnitudes, form the *Square of Pegasus*, and appear nearly half way between the eastern horizon and the meridian.

All the stars alluded to above may likewise be seen during the months of July and August, when they will appear in a more *easterly* position than at the time stated above; and in the month of October, at eight o'clock, and in November, at six o'clock in the evening, they will be seen nearly in the positions which have been now represented.

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Plate III. represents a view of some of the principal stars around the pole, extending from the polar point, in every direction, about forty-five degrees. In using this map, the observer is supposed to be looking towards the north, in which case the left-hand side of the map is towards the *west*, and the right side towards the *east*. The large star near the centre of the map is the Pole-star, which forms the tip of the tail of *Ursa Minor*, the square of which, and the two other stars in the tail, will be seen ascending from it towards the right hand, when the map is so placed that the 1st of April is at the top. There is only one star of the first magnitude within the limits of this map, namely, *Capella*, the principal star in the constellation *Auriga*, opposite that part of the map where the month of December is marked. A line drawn from *C* to *D* passes through this star, which is adjacent to the extremity of the map. There are eleven stars of the second magnitude; five in the square and tail of *Ursa Major*, or the Great Bear, namely, the two pointers, *Dubbe* and *Merak*. *Phad*, *Alioth*, and *Benetnach* The others are, *Menkalina*, *Etanim*, *Rastaban*. *Algenib*, *Delta Cygni*, and the *Pole-star*. A line drawn from *A* to *B* passes through Dubbe and Merak, and the Pole-star, at the centre of the map; and on the other side of the Pole-star it passes through a part of the constellation of *Cassiopeia*, the Pole-star being nearly equidistant between that constellation and the pointers. A line drawn from *E* to *F* passes through *Menkalina*, in the constellation of Auriga, about eight degrees from Capella. A line drawn from *G* to *H* passes through *Delta Cygni*, in the Swan, which is placed at the extremity of the map. A line from *I* to *K* passes through Algenib, the principal star in the constellation of *Perseus*. A line from *L* to *M* passes through *Etanim*, near the right-hand side of the map, a star of the second magnitude in the constellation of *Draco*, near to which, at the distance of four or five degrees, is *Rastaban*, likewise a star of the second magnitude in the same constellation. With two other stars, they form a kind of irregular square or trapezium, and, with another small star, they form a figure resembling an Italic *V*. When the star Etanim comes to the meridian of London, it is exactly in the zenith of that place, which has rendered it of peculiar utility in certain nice astronomical observations. It is celebrated in modern times as being the star which Dr. Bradley selected to determine, if possible, the *Annual Paral-*

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lax; and from his observations of which he deduced the important discovery of the *Aberration of Light.*

Let us now suppose that we are to contemplate the northern part of the heavens about the beginning of *April*, at ten o'clock in the evening. Turning our faces towards the Pole-star, or directly north, and holding that part of the map uppermost which is opposite to the beginning of April, those stars which are marked on the *upper* part of the map will appear not far from the zenith, or nearly overhead; those towards the lower part will appear at a low elevation, not far from the horizon; those on the right will appear in the east, and those on the left in the west, at different elevations, as here represented. The two pointers in the Great Bear, which are directly opposite to the 1st of April, will be seen nearly in the zenith, and to point *downward* to the Pole-star; and, at nearly an equal distance below the Pole-star, they direct the eye to the constellation *Cassiopeia*, which is conceived to have a certain resemblance to a *chair*, and which appears only a small distance above the northern horizon. To the west or left-hand side of Cassiopeia is the constellation *Perseus*, of which Algenib is the principal star, and which is likewise at a low elevation. To the right, or east side of Cassiopeia, is *Cepheus*; four stars of which, two of the third and two of the fourth magnitude, form a kind of square, or rhombus. The stars farther to the east, and in a more elevated position, belong chiefly to the constellation of *Draco*, or the Dragon. The star *Etanim*, in this constellation, appears nearly due east of the Pole-star, at the distance of forty degrees. The stars on the western side of the map, or on the left hand, nearly opposite to Etanim, belong to the constellation of Auriga; and those on the upper part are chiefly some of the prominent stars connected with the Great Bear. The bright star Capella appears nearly west by south from the Pole-star, at a pretty high elevation, with *Menkalina* a little above it, and to the eastward.

Besides the stars marked on the map, there may be seen, at the same time, several brilliant stars of the first magnitude. Turning the eye east by south, the bright star *Arcturus*, in the constellation *Bootes*, is seen about half way between the horizon and the zenith. Looking to the northeast, the brilliant star *Vega*, or Lyra, appears elevated twenty degrees above the horizon, in a direction nearly opposite to Capella,

in the west. Farther to the north, but not quite so elevated as Lyra, is *Deneb*, in the constellation of the Swan. Turning our eye to the west, Castor and Pollux will be seen about midway between the western horizon and the zenith; and farther down, near the horizon, almost due west, are Betelguese and Bellatrix, the two stars in the shoulders of Orion, Betelguese appearing the more elevated of the two, the other portions of Orion having descended below the horizon. To the southwest, midway between Pollux and the horizon, is *Procyon*, a star of the first magnitude in the Lesser Dog.

Suppose, now, we were to observe the same quarter of the heavens, at the same hour, about the beginning of October. In this case we have only to reverse the map, so that the first of October may be uppermost. At this season, Cassiopeia will appear near the zenith, and the two pointers of Ursa Major will be seen at the opposite side of the pole, at no great elevation above the horizon. Capella will appear towards the east, on the right, at a considerable altitude, and the five stars in the head of Draco considerably to the west, while Algenib, and the other stars in Perseus, will be seen in a high elevation, to the east of Cassiopeia. At this time, likewise, by turning our eyes towards the east and the south, Aldebaran, or the Bull's-eye, in the constellation Taurus, will be seen elevated about twelve degrees above the eastern horizon, about sixteen degrees above which are the Pleiades, or seven stars. The star Altair will appear near the southwest, half way between that point and the meridian, and *Fomalhaut*, in the Southern Fish, will be seen nearly on the meridian, only five or six degrees above the south point of the horizon.

In like manner, were we wishing to observe the position of the circumpolar stars *at any other hour*, at this period, than ten o'clock P.M., suppose at eight in the evening, we have only to turn the line which marks the beginning of September uppermost instead of October, and the position at that hour will be seen; and if we choose to make our observations at six in the evening, we turn the first of August to the top, allowing two hours, at an average, for every month. If we would inspect their position at twelve midnight, the first of November must be turned round to the top, and so on for any other hour. If we would make our observations in the beginning of January, at ten P.M., that point must be turned to the top, and then the two pointers will be seen on the right,

straight east from the Pole-star, and the other five stars hanging down from them, Cassiopeia nearly straight west, and Capella not far from the zenith. These circumpolar stars may therefore be seen at every season of the year, and their relative positions determined beforehand by simply turning round the map to the month, or day of the month, required, so that that point may be at the top, and although the months are arranged so as to correspond with ten o'clock P.M., yet the positions may be represented for any other hour, according to the directions given above.

The following remarks may be stated in reference to the stars depicted on this map: 1. All these stars never set in our latitude, but appear to move round *above* the horizon in circles, of which the pole is the centre. As the observer is supposed to be in fifty-two degrees N. latitude, all the stars within 52° of the pole never descend below the horizon. In one part of their diurnal course they appear above the pole, and some of them near the zenith, and in the opposite point they appear below the polar point, and sometimes near the northern horizon. 2. In the higher part of their course they appear to move from east to west, and in the lower part from west to east. Those nearest the pole describe small circles around the polar point; and those at greater distances describe larger circles; but their periods of apparent revolution are exactly the same, namely, twenty-three hours, fifty-six minutes, and four seconds. 3. The stars represented in this map are only those which are most prominent and obvious to the naked eye, in order to prevent confusion, and that the untutored observer may not be distracted with too many objects at one view. They chiefly consist of stars of the second, third, and fourth magnitudes. 4. In order that the observer may be able readily to estimate the apparent distances of the stars from each other and from the horizon, it may be proper to keep in mind that the distance between the two pointers is exactly five degrees, and between Dubbe (the nearest to the pole) and the Pole-star, twenty-nine degrees. By applying these measures by the eye to other stars, their apparent distances may be very nearly estimated. 5. Although I have stated, in general terms, that the pointers come to the southern meridian, or are nearly in the zenith, at ten P.M., *about the beginning* of April, yet it is not before the seventh of this month that they are accurately in this position at ten in the evening; but the differ-

ence is not much perceptible by the eye during the course of a week or two, and therefore can lead to no great mistake. 6. If the circle containing the stars were cut out, and surrounded with the circle of months and days, and made to revolve within the circle of hours, it might be made to serve the purpose of an astronomical clock for pointing out the hours of the night, and likewise for showing the positions of the circumpolar stars for any hour of the day or night. 7. The delineations of the apparent distances of the stars on this map are on a scale of only one half the size of that on which the two preceding maps were constructed.

The three preceding views of certain portions of the heavens, partly delineated from actual observation, are intended to convey to general observers a *natural* representation of those quarters of the firmament to which they refer, so that by a little farther attention and observation, and an inspection of a celestial atlas, they may acquire a general view of the principal stars and constellations visible in our hemisphere; for on most celestial planispheres and globes there is such a group of eyes, noses, legs, tails, claws, and wings connected with the mythological figures of the constellations, no traces of which can be seen in the heavens, that the learner is sometimes confounded, and can scarcely trace any resemblance between what is depicted on such globes and planispheres and the real aspect of the firmament, the stars appearing, in many instances, as accidental spots, buried, as it were, amid the group of hieroglyphics with which they are connected.

CHAPTER II.

ON THE ARRANGEMENT OF THE STARS INTO CONSTELLATIONS, WITH SKETCHES OF THEIR MYTHOLOGICAL HISTORY.

In order to distinguish the stars from one another, the ancients divided the heavens into different portions or spaces, called *constellations*, or groups of stars. They supposed each group to occupy a space which a lion, a bear, a man, a harp, or other object would fill if it were there delineated; and

hence the different constellations were depicted as if they had borne a resemblance to dragons, dogs, rams, altars, ships, and similar objects, whether imaginary or real. The invention of the constellations, particularly those of the Zodiac, is generally attributed to the Chaldeans or the Egyptians; but most probably the merit, such as it is, is due to the former, although the Egyptians appear at a very early period to have derived the knowledge of astronomy from the inhabitants of Chaldea, and imparted it to the ancient Greeks and other nations. The first series of constellations which were formed appear to have been those of the Zodiac. Finding that the year consisted neither of twelve nor of thirteen lunations, in order to know the precise bounds of the annual course of the sun, they were under the necessity of carefully examining what stars were successively obscured in the evening by the motion of that globe, and what stars, after emerging from its rays, showed themselves again before the dawn of day.

Macrobius, an ancient Roman author, and Sextus Empiricus, a Greek writer, have handed down to us the ingenious method which the first astronomers used to determine exactly the course which the sun describes in the heavens, and to divide the year into equal portions, of which the following is a condensed description:

They every day saw the sun and the whole heavens turning round from east to west. In the mean time they observed that the sun, by a motion peculiar to it, receded, from day to day, from certain stars, and took its place under others, always advancing towards the east. As they found that twelve revolutions of the moon approximated to one revolution of the sun, but that a certain sensible difference existed, they wished that they might have twelve divisions of the year, which might be *exactly* equivalent to the year itself. For this purpose they took two brass open vessels, the one pierced at the bottom, and the other without any orifice below. Having stopped the hole of the first, they filled it with water, and placed it so that the water might run out into the other vessel the moment the cock should be opened. This done, they observed in that part of the heavens where the sun has its annual course the rising of a star, remarkable either for its magnitude or its brightness, and at the critical instant it appeared on the horizon they began to let the water flow out of the upper vessel into the other during the rest of the night and

the whole following day, till the very moment when the same star began to appear anew on the horizon. The instant it was again seen they took away the under vessel, and threw the water that remained in the upper on the ground. The observers were thus sure of having one revolution of the whole heaven between the first rising of the star and its return. The water which had flowed during that time now afforded them the means of measuring the duration of one whole revolution of the starry firmament, and of dividing that duration into several equal portions. They then divided the water of the under vessel into twelve parts, *perfectly equal*, and prepared two other small vessels capable of containing exactly one of these portions, and no more. They again poured into the great copper vessel the twelve parts of water all at once, keeping the vessels shut. They then placed under the cock, still shut, one of the two small vessels, and another near it to succeed the first as soon as it should be full. All these preparations being ready, the next night they observed that part of the heavens towards which they had remarked the sun took his course, and waited for the rising of the constellation which has since been called *Aries*. The instant Aries appeared, and they saw the first star of it ascending, they let the water run into the little measure. As soon as it was full they removed it, and threw the water out. In the mean time they put the other empty measure under the fall. They observed accurately all the stars that rose during all the periods which the measure took in filling, and that part of the heavens was terminated in their observations by the star which appeared last on the horizon the moment the measure was just full. In like manner they proceeded with the other vessel alternately, till the two small vessels were three times filled, which marked out six divisions, or one half of the course of the sun in the heavens. They were then forced to defer the observation and measurement of the other half of the firmament till the opposite season of the year, when they proceeded as before.

Having in this manner determined the twelve divisions of the heavens, and marked the clusters of stars peculiar to each, they proceeded to give them names, and, in general, termed them the stations or *houses* of the sun, three of which were assigned to each season. The particular names given to each of the twelve constellations of the Zodiac are generally sup-

posed to refer to certain circumstances peculiar to the different months. As the Chaldean observers seem to have been of opinion that there were, during the spring, no productions more useful than lambs, calves, and rams, they gave the constellations through which the sun passes during that season the names of the three animals by which they were most enriched. The first was named *Aries*, or the Ram; the second *Taurus*, or the Bull; and the third *Gemini*, or the Twins, that is, the two goats, which commonly bring forth two young at a time. The Greeks afterward represented them by Castor and Pollux, two twin brothers, sons of Jupiter by Leda, the wife of Tyndarus, and as such are represented on our globes. Having remarked that there was a point to which the sun approached when passing these signs, but which it never went beyond, and that it afterward receded from that point for six months together, this retreat of the sun backward led them to distinguish it by the name of an animal which walks backward, and hence it was denominated *Cancer*, or the Crab. As the heats in the next month (July) are most intense, they compared them to the raging and fierceness of a lion, and hence they called the sign *Leo*, that is, the Lion. As in the next month harvest commences, and as young girls were generally set to *glean* in the fields, they denominated the sign corresponding to this month *Virgo*, or the Virgin, which is represented by the figure of a young woman holding an ear of corn.

The perfect equality of days and nights which happens when the sun quits the sign of Virgo caused astronomers to give the next sign the name of *Libra*, that is, the Balance, poised so as to represent equal day and night. The frequent diseases which are produced in consequence of the sun retiring to the south procured the next sign the name of *Scorpio*, or the Scorpion, because it is mischievous, and drags after it a sting and venom. When harvest is over, and the fields cleared of the crops, then is the season for hunting, and therefore the sign in which the sun enters at that time has obtained the name of *Sagittarius*, that is, the Archer, or Huntsman. The next constellation, *Capricorn*, had its origin from the wild goat, whose nature being to seek its food from the bottom to the top of mountains, was considered emblematic of the ascent of the sun from the lowest point of its course, in the beginning of this sign, to its highest pitch or summit in

the summer solstice, when it enters the sign Cancer. The next sign is called *Aquarius*, or the Water bearer, emblematical of the rains which generally fall at this season of the year; and the last sign is named *Pisces*, or the Fishes, which name seems to have been given because at the time when the sun enters it fishes are then considered as fattest and most in season for use.

Such were the names and the symbols which the ancients appropriated to that great circle or zone of the heavens through which the sun, moon, and planets appeared to move. As the names of ten of these signs or constellations are borrowed from several animals, astronomers gave the annual zone which they compose the name of *the Zodiac*, that is, the circle of animals, from the Greek word ζωον, an animal. By this division of the heavens, mankind acquired a new method of measuring time, and of regulating all their labours. From the knowledge of the year and of its several subdivisions, and the periods when sowing ought to commence, and when the fruits of harvest might be expected to arrive at maturity. When, after the setting of the sun, they saw the stars of the sign *Aries* ascend the opposite horizon, and distant from the sun by one half of the sphere of the heavens, they then knew that the sun was under the sign *Libra*, which, being the seventh of the celestial signs, was distant from the first by one half of the whole Zodiac. When, at the approach of day, they saw, in the middle of the firmament or on their meridian, at an equal distance from east to west, the principal star of the sign *Leo*, they understood that the sun, then about to rise, was at the distance of *three* signs from Leo, and removed towards the east one fourth part of its circle. Thus, without seeing the stars, which were obscured and overpowered by the sun's rays as he passed through them, they could say, with a perfect assurance, "the sun is now in *Scorpio*, and in two months hence the shortest day will arrive." On the sight of a single constellation, placed either in the eastern, western, or middle part of the heavens, they could immediately tell in what sign the sun was, how far the year was advanced, and what kinds of labour were requisite to be performed. It is therefore to astronomy we are originally indebted for our knowledge of the length of the year and the commencement of its different seasons.

The ancients next proceeded to arrange into constellations

the other groups of stars which were situated to the north and south of the Zodiac. In forming this arrangement they proceeded on principles similar to those by which they had delineated the signs of the Zodiac. They conceived the different groups as if they bore a certain resemblance to birds, beasts, serpents, or to certain imaginary beings, and gave them names corresponding to such conceptions. This they seem to have done for the sake of assisting the memory and imagination in forming a general idea of the forms and the relative position of the several clusters of stars, and to enable the observer more readily to distinguish and to point out any particular star; but it would be too tedious, and would convey little profitable instruction, to inquire into the reasons of the emblematical figures they adopted, or to attempt a detailed view of their mythological history.

The following table contains a list of all the constellations, ancient and modern, with the number of stars in each, as stated in the *Historia Celestis* of *Flamstead*, formerly Royal Professor of Astronomy at Greenwich. The first column contains the *name* of the constellation, the second column the number of stars it contains, and the third column the principal stars and their magnitudes. The number 1 expresses stars of the first magnitude; 2, those of the second magnitude, &c.

NORTHERN CONSTELLATIONS.

Name.	No. of Stars.	Principal Stars.
Ursa Minor—the Little Bear	24	Pole Star, 2.
Ursa Major—the Great Bear	87	Dubhe, 1; Alioth, 2.
Draco—the Dragon	80	Rastaben, 2.
Cepheus (East of Draco)	35	Alderamin. 3.
Bootes—the Herdsman	54	Arcturus, 1; Mirac, 3.
Corona Borealis—the Northern Crown (East of Bootes)	21	Alphecca, 2.
Hercules, with Cerberus	113	Ras Algethi, 2.
Lyra—the Harp	21	*Vega*, or Lyra, 1.
Cygnus—the Swan	81	Deneb, 2.
Cassiopeia—Lady in her chair	55	Schedir, 3.
Perseus, and Head of Medusa	59	Algenib, 2; Algol, 2.
Auriga—the Wagoner	66	Capella, Alajoth, 1.
Serpentarius—Serpent Bearer	74	Ras Alhague, 2.
Serpens—the Serpent	64	
Sagitta—the Arrow (North of Aquila)	18	
Aquila and Antinous—the Eagle, &c.	71	Altair, 1 or 2.
Delphinus—the Dolphin	18	
Equuleus—the Horse's Head	10	
Pegasus—the Flying Horse	89	Markab, 2; Scheat, 2.

Name.	No. of Stars.	Principal Stars.
Andromeda	66	.. Alamak, 2; Mirack.
Triangulum—the Triangle	16	
Camelopardalis—Camelopard	58	
Leo Minor—the Little Lion	53	
Coma Bernices—Bernice's Hair (North of Virgo)	43	
Vulpecula et Anser—the Fox & Goose (South of Cygnus)	35	
Lacerto—the Lizard (East of Cygnus)	16	
Scutum Sobieski (North of Sagittarius)	8	
Canis Venatici—the Greyhounds	25	
Lynx	44	
Cerberus	4	
Mons Menelaus (Southeast of Bootes)	11	
Taurus Poniatowski—the Bull of Poniatowski (West of Aquila)	7	
Musca—the Fly (North of Aries)	6	
Tarandus—Reindeer (at North Pole	12	
Total number of stars in the Northern Constellations	1444	

SOUTHERN CONSTELLATIONS.

Those Constellations marked thus † never rise in N. lat. 52 degrees.

Name.	No. of Stars.	Principal Stars.
Cetus—the Whale	97	.. Menkar, 2; Mira, 2.
Orion	78	.. Betelguese, 1; Rigel, 1
Eridanus—the River Po	84	.. Achernar, 1.
Lepus—the Hare (South of Orion)	19	
Canis Major—the Great Dog	31	.. Sirius, 1.
Canis Minor (North of Monoceros)	14	.. Procyon, 1.
Argo Navis—the Ship Argo	64	.. Canopus, 1; Naos, 2.
Hydra—the Serpent	60	.. Cor Hydræ, 1.
Crater—the Cup (South of Virgo)	31	.. Algorab, 3.
Corvus—the Crow (South of Virgo)	9	.. Alkes, 3.
Centaurus—the Centaur	35	
Lupus—the Wolf	24	
Ara†—the Altar	9	
Corona Australis—Southern Crown	12	
Piscis Australis (South of Aquarius)	24	.. Fomalhaut, 1.
Columbo Noachi—Noah's Dove	10	
Robur Caroli† (East of Argo Navis)	12	
Grus†—the Crane	13	
Phœnix†	13	
Indus†—the Indian	12	
Pavo†—the Peacock	14	
Apus†—the Bird of Paradise	11	
Apis Musca† Australis	4	
Triangulum Australis† (South Triangle)	5	
Piscis Volans†—the Flying Fish	8	
Cameliou† (near the South Pole)	10	
Dorado†—the Sword Fish	6	

Name.	No. of Stars.
Toucan†—the American Goose	9
Hydrus†—the Water Snake	10
Sextans—the Sextant (South of Leo)	41
Monoceros—the Unicorn	31
Crux—the Cross†	6
The Sculptor's Apparatus	12
Circinus†—the Compasses	7
Brandenburgium Sceptrum (Southwest of Orion)	6
Equuleus Pictorius	8
Fornax Chemica	14
Horologium†—the Clock	12
Mons Mensa†—the Table Mountain	30
Machina Pneumatica—the Air Pump	24
Norma, or Euclid's Square	12
Octans Hadleianus†—Hadley's Octant	43
Pyxis Nautica—Mariner's Compass	8
Reticula Rhomboidali †	10
Telescopium†—the Telescope	9
Sculptorio†—the Engraver's Tools	16
Microscopium—the Microscope	10
Total number of stars in the Southern Constellations	1027

ZODIACAL CONSTELLATIONS.

Name.	No. of Stars.	Principal Stars.
Aries—the Ram	66	α Arietis, 2.
Taurus—the Bull.	141	Aldebaran, 1 : Pleiades
Gemini—the Twins	85	Castor, 1 : Pollux, 1.
Cancer—the Crab	83	Acubens, 3.
Leo—the Lion	95	Regulus, 1 ; Denebola, 2.
Virgo—the Virgin	110	Spica Virginis, 1.
Libra—the Balance	51	Zubeneschamale, 2
Scorpio—the Scorpion	44	Antares, 1.
Sagittarius—the Archer	69	
Capricornus—the Goat	51	
Aquarius—the Water Bearer	108	Scheat, 3.
Pisces—the Fishes	113	
Total number of stars in the Zodiac	1016	

Total number of stars in all the Constellations........3487.

Thus all the visible stars in the firmament have been arranged into ninety-four constellations, of which forty-eight were formed by the ancients, and the rest within the last two or three hundred years. Of the stars above enumerated, there are about 17 of the first magnitude, 76 of the second, 223 of the third, and the remainder of the fourth, fifth, and sixth

magnitudes. The different classes of magnitudes are intended to express their apparent brightness. The brightest stars are said to be of the first magnitude; those which appear next in brightness, or inferior to the first, are classed in the second magnitude; and so on down to the sixth magnitude, which comprises the smallest stars visible to the naked eye in the clearest night; though there are but few eyes that can distinguish those which belong to the sixth magnitude. All the stars beyond these limits come under the general denomination of *Telescopic stars;* and with the most powerful telescopes, stars may be perceived of all classes, from the sixth to the sixteenth order of magnitudes. Every increase in the power of these instruments brings into view innumerable multitudes of those orbs which were before invisible, so that no definite limits can be assigned to the apparent brightness or magnitudes of the stars This classification into magnitudes, however, as it is entirely arbitrary, so it is extremely indefinite, and can convey no very accurate ideas even of their *apparent* brightness or intensity of light. This consideration has led some eminent astronomers to endeavour to estimate the apparent brightness of each star by experiments made with the photometer. From various experimental comparisons of this kind, the late Sir Wm. Herschel deduced the following conclusions:

Light of a star of the average	1st	magnitude	= 100
	2d	.	= 25
	3d	.	= 12
	4th	.	= 6
	5th	.	= 2
	6th	.	= 1

So that the light of a star of the second magnitude is one fourth of that of a star of the first magnitude; the light of one of the third, one eighth; of the fourth, one sixteenth; of the fifth, one fiftieth; and of the sixth, only one hundredth part. Sir John Herschel informs us that, from his own experiments, he has found that the light of *Sirius*, the brightest of all the fixed stars, is about 324 times that of an average star of the sixth magnitude.

It may be proper to observe that the stars specified in the statements inserted above are not all visible to the naked eye, nearly two thirds of them being perceptible only by the tele-

scope; but they are those stars whose latitudes and longitudes, and whose right ascensions and declinations, have been accurately determined. They form only *a very small proportion* of those which are found to exist in the most distant regions of the firmament; for by powerful telescopes there have been explored in a single speck of the heavens a number which far exceeds that of all the visible stars in the sky; and catalogues have been formed in modern times which comprise from fifty to a hundred thousand of these luminaries.

The first astronomer, so far as we know, who attempted to make a catalogue of the stars, was *Hipparchus* of Rhodes, who flourished about 120 years before Christ. Having observed a new star which he had never seen before, he began to doubt whether there might not be changes occasionally taking place among these luminaries, and therefore commenced making a catalogue of them, noting down the position and magnitude of each star, with the view that, if any new star should again appear, or any of those observed by him should increase or be diminished in magnitude, or totally disappear, such changes might be known to those who should live in future ages. This catalogue, which was handed down to us by Ptolemy, an ancient Egyptian astronomer, has been of special use to modern astronomers, both in determining the rate of the precession of the equinoxes, and in proving that certain stars which then existed are no longer to be seen in the heavens; thus indicating that changes and revolutions are taking place among the distant bodies of the universe. The catalogue of Hipparchus contained a description of the places of 1026 stars. The Arabians are the next whom history represents as having attempted to form a descriptive catalogue of the stars. This was effected by *Ulug Beigh*, the grandson of Timurlane, from his own observations made at Samarcand, whose catalogue contains 1022 stars. Tycho Brahe, the celebrated Danish astronomer, who lived in the sixteenth century, by means of the large and accurate instruments he invented, formed a catalogue of 777 stars, which are considered as superior in correctness to those of Hipparchus and Ulug Beigh. He was prompted to this laborious undertaking by the sudden appearance of a new star in Cassiopeia, in the year 1572, which shone with the brilliancy of Venus, and was visible even at noonday. *Bayer* soon after published a catalogue of 1160 stars, in which he introduced the practice of distinguishing the

stars by the letters of the Greek alphabet. All the catalogues now mentioned were formed before the telescope was invented, and contained nearly all the stars which could be perceived by the unassisted eye. Soon after the invention of the telescope, in the beginning of the seventeenth century, the celebrated Hevelius composed a catalogue of 1888 stars, of which 1553 were observed by himself, and their places computed for the year 1660. But some of our modern observers of the heavens have published catalogues which contain the positions of many thousands of stars, besides multitudes of nebulæ, of various descriptions, double, triple, and quadruple stars, and various other celestial phenomena.

The division of the heavens into constellations, and the names and figures by which they are distinguished, seem to have been of a very ancient date. Job, who is supposed to have lived in a period prior to that of Moses, refers to some of them by the same names which they still bear. "Canst thou bind the sweet influences of *Pleiades*"—or the seven stars—"or loose the bands of Orion?" that is, the *belt* of Orion, which consists of three equidistant stars in a straight line. "Canst thou bring forth Mazzaroth in his season? or canst thou guide Arcturus with his sons?" Arcturus is a bright star of the first magnitude in the constellation of Bootes, and is here put for the constellation itself. The expression "his sons" is supposed to refer to *Asterion* and *Chara*, the two Greyhounds, with which he seems to be pursuing the Great Bear around the North Pole in the diurnal revolution of the heavens. *Mazzaroth* is generally supposed to refer to the twelve signs of the zodiac, which, by their appointed revolutions, produce the succession of day and night, and the seasons of the year. In another part of this book, Job, when filled with profound reverence of the majesty of God, declares that He alone "spreadeth out the heavens, and maketh Arcturus, Orion, and the Chambers of the South." The prophet Amos, who lived 800 years before the Christian era, alludes to the same objects in the fifth chapter of his prophecy: "Ye who turn judgment to wormwood, and leave off righteousness in the earth, seek Him who maketh the seven stars and Orion, who turneth the shadow of death into the morning, and maketh the day dark with night; that calleth for the waters of the sea, and poureth them out upon the face of the earth: the Lord of Hosts is his name."

The names of the constellations, and the hieroglyphic figures by which they are represented, appear, however, to have had their origin in superstitious and idolatrous notions. The Egyptians, it is well known, worshipped the host of heaven under the figures of most of the animals which represent the celestial constellations, particularly the signs of the Zodiac. They imagined the sun, which they called *Osiris*, to be a proper representative of the Spirit of Nature, or the Supreme Being, who, like the sun, appears everywhere present, exercising his influence over the universe. The moon, as she receives her light from the sun, was looked upon as a female divinity, and called *Isis*; which goddess was made to signify universal nature considered as passive, and susceptible of various impressions, forms, and qualities. They found, or imagined they found, in various animals some properties or qualities corresponding to the motions, appearances, or influences of the sun, moon, and stars. This induced them not only to use those animals in their hieroglyphic representations of their deities, but also to pay them divine honours. Thus, by the *Ram*, a prolific animal, they represented the genial, fertilizing influence of the sun in spring; and by the hot and furious *Lion*, his violent scorching heat in the summer; and the Bull was an emblem of the various powers of the sun in forwarding the business of agriculture, in which this animal was of particular service. As the overflowing of the Nile is particularly beneficial to the land of Egypt, and as that river was observed to swell at the rising of Sirius, or the Dog Star, so they had a special veneration for that orb, as if its divine influence had contributed to that fertility which was produced by the inundation of the Nile. That the Egyptians worshipped all the animals depicted on the Zodiac, and those which represent several of the other constellations, is proved by the testimony of several ancient authors, particularly Herodotus, who says that "in Egypt all sorts of beasts, whether wild or tame, were accounted as sacred, and received divine honours." And it is not improbable that this worship of the host of heaven, through the hieroglyphics of various animals, was a general practice during the abode of the children of Israel in that country, and that the following admonition of Moses has a reference to this circumstance: "Take heed lest ye corrupt yourselves and make you a graven image, the similitude of any figure, the likeness of male or female, the likeness of any

beast that is on the earth, the likeness of any fowl that flieth in the air, the likeness of anything that creepeth upon the ground, the likeness of any fish that is in the waters beneath the earth; and lest thou lift up thine eyes to heaven, and when thou seest the sun, and the moon, and the stars, even all the host of heaven, shouldst be driven to worship them and serve them, which the Lord thy God hath divided unto all nations under the whole heaven. But the Lord thy God hath taken you and brought you forth out of the iron furnace, even out of Egypt." The reference here made to their being brought out of Egypt seems evidently intended to put the Israelites in mind of their deliverance *from the idolatrous practices* of the inhabitants of that country, as well as from the slavery to which they had been subjected, and consequently implies that the Egyptians indulged in the superstitious worship to which we have alluded.

As it is the practice of astronomers to denote the relative apparent magnitudes of the stars in each constellation by the letters of the Greek alphabet, the whole of this alphabet is here inserted, that the unlearned reader may be enabled to distinguish the different characters, and the order in which they follow each other.

The first letter of the Greek alphabet, *α*, denotes the largest or brightest star in each constellation. Thus, *α* Lyræ is the brightest in the constellation of Lyra, or the Lyre; *β* Lyræ, the star next in brightness to alpha; and so on throughout all the letters of the Greek alphabet. When the number of stars to be distinguished in any constellation is greater than the number of letters in the Greek alphabet, astronomers have recourse to the letters of the English alphabet, and distinguish the remaining stars, according to their apparent brilliancy, by the letters a, b, c, d, &c.; and if more stars still remain to be distinguished, they resort to numerals, thus a^2, d^4, &c. From this mode of distinguishing the apparent magnitude of the stars, the reader will easily perceive that those stars which are distinguished by the first letters of the Greek alphabet are the largest in any particular constellation, while those which are marked with letters towards the close of the alphabet are among the smaller stars.

GREEK ALPHABET.

Greek Characters.	Names.	Greek Capitals.	Roman Characters.
α	Alpha	Α	a
β	Beta	Β	b
γ	Gamma	Γ	g
δ	Delta	Δ	d
ε	Epsilon	Ε	e, short
ζ	Zeta	Ζ	z
η	Eta	Η	e, long
ϑ θ	Theta	Θ	th
ι	Iota	Ι	i
κ	Kappa	Κ	k
λ	Lambda	Λ	l
μ	Mu	Μ	m
ν	Nu	Ν	n
ξ	Xi	Ξ	x
ο	Omicron	Ο	o, short
π	Pi	Π	p
ρ	Rho	Ρ	r
σ ς	Sigma	Σ	s
τ	Tau	Τ	t
υ	Upsilon	Υ	u
φ	Phi	Φ	ph
χ	Chi	Χ	ch
ψ	Psi	Ψ	ps
ω	Omega	Ω	o, long.

CHAPTER III.

ON THE PROPRIETY OF ADOPTING A MORE NATURAL ARRANGEMENT AND DELINEATION OF THE STARRY GROUPS.

THE figures of the celestial constellations to which we have now adverted are still depicted on our celestial globes and planispheres, and present, in my opinion, a very awkward and *unnatural* representation of the starry heavens. It is rather a strange circumstance that, for a period of more than two thousand years, the firmament has been contemplated, and the arrangements of the bodies it contains studied, through the medium of bears, serpents, lizards, rams, whales, centaurs, dolphins, flying horses, three-headed dogs, hydras, dragons, and many other grotesque and incongruous figures. The sublime wonders of the evening sky have thus been associ-

ated with a group of mean, ridiculous, and imaginary objects, of which we have scarcely any prototype in nature, and in which there is not the least shadow of a resemblance to the objects which they are intended to represent. When the young student of astronomy wishes to distinguish particular assemblages of suns and systems of worlds, he is required to connect them in his imagination with wolves, lions, snakes, and numerous fantastical figures, which are bent and twisted into unnatural shapes, which have as little resemblance to the objects in the heavens as the gloom of midnight to the splendours of the meridian sun. Such representations have a tendency to convey to juvenile minds a mean idea of the most august bodies in nature, and of the ample spaces which surround them, and in which they perform their revolutions.

The terms used in any science, the mode of communicating its instructions, and the delineations which such instructions require, ought undoubtedly to be accommodated to the discoveries which have been made in the course of ages, and to the present state and objects of that science; and unless we can show that the terms and figures to which I allude are the best calculated to the present state and objects of astronomical science, and fitted to assist the student in forming natural and correct ideas of the arrangement of the celestial orbs, it is expedient that some change and improvement in this respect should be adopted, in accordance with the new modifications and arrangements which have been introduced into other departments of science. The propriety of introducing some changes in delineating the constellations, and in their nomenclature, may perhaps appear from the following considerations:

1. The natural and hieroglyphic figures now in use have no resemblance to the groups of stars they are intended to represent. What resemblance, for example, exists between an eagle, a wolf, a centaur, a flying-fish, or Hercules with his club, and the constellations which bear their names and are attempted to be delineated by their figures? Even when imagination has stretched itself to the utmost in order to fancy a resemblance, it is obliged to represent such creatures in the most unnatural positions; and, after all, it is found impossible to bend and twist their wings, and legs, and tails, and claws, in such a manner as to take in all the stars in the group, some pretty conspicuous ones being still left unformed in the

intermediate spaces. Besides, the discovery of new stars by the telescope has now completely deranged the figures of the ancient constellations; so that, however much the legs, arms, and feet of the figures may be twisted, they cannot be made to coincide with hundreds of stars which are known to exist. The only constellations which may be said to bear a very rude resemblance to the natural figures are Orion and Ursa Major; but even in these the resemblance is very distant. Hence what is commonly called a *bear* is also conceived to resemble a *plough* and a *wagon*, and is, by the vulgar, distinguished by these names. Hence, also, different nations represent the same constellation by different figures: thus, instead of our hieroglyphic delineations, the Hindoos have bespattered the firmament with bedsteads, dogs' tails, ear-rings, couches, elephants' teeth, cats' claws, red saffron, children's pencils, lions' tails, festoons, wheels, razors, pieces of coral, pearls, and other whimsical objects equally appropriate.*

In a judicious comparison of the figures of the different clusters of stars with any other object, for the purpose of a name or reference, the figure of the particular cluster ought first to be accurately considered, and then an object, having as near a relation to it as possible, should be fixed upon as its representation. But an order exactly the reverse of this seems to have been adopted by the ancients in their arrangement and nomenclature of the constellations. They first fixed upon the heroes, animals, and mythological figures which they intended to place in the celestial vault, and then attempted, if possible, to bend the clusters of stars to correspond with them: a most absurd, unscientific, and unnatural procedure. And shall all succeeding astronomers in every nation tacitly give their approbation of such rude and injudicious arrangements, as if they were unqualified for forming a more scientific and definite outline of the sublime spaces of the firmament?

2. The figures now in use tend to convey a mean idea of the objects they are intended to represent. When the stars were considered as merely a number of tapers or studs fixed in the vault of heaven, solely for the purpose of shedding a few glimmering rays on the earth and adorning the canopy of our habitation, it might not appear quite so incongruous to

* See "Asiatic Researches," vol. ii., art. 16—Antiquity of the Indian Zodiac.

represent their different groups by "corruptible men, and birds, and four-footed beasts, and creeping things." But now that the astronomer views the stars as so many suns and systems of worlds, dispersed through the immensity of space, the association of such august objects with representations so silly and whimsical as the mythological figures delineated on our globes, produces not only a ludicrous effect by the greatness of the contrast, but, for the same reason, tends to lessen the idea of sublimity which naturally strikes the mind on the contemplation of such a stupendous scene. Every one knows how much things great and noble are debased by being placed in intimate connexion with little and ignoble objects, and must feel the force of this association in the following lines of Hudibras:

> "And now had Phœbus in the lap
> Of Thetis taken out his nap;
> And, like a lobster boil'd, the morn
> From black to red began to turn."

Again:

> "Cardan believed great states depend
> Upon the tip of the Bear's tail's end;
> That as he whisk'd it towards the sun,
> Strew'd mighty empires up and down."

And again:

> "Who made the *Balance*, and whence came
> The *Bull*, the *Lion*, and the *Ram*?
> Did not we here the *Argo* rig?
> Make Berenice's periwig?
> Whose livery does the *Coachman* wear?
> Or who made *Cassiopeia's* chair?
> And therefore as they came from hence,
> With us may hold intelligence."

Such an effect the celestial hieroglyphics have a tendency to produce when placed in association with the august objects of the sky.

3. They tend to lead us back to the dark and rude ages of the world, and to familiarize our minds to those crude, chimerical, and absurd conceptions which ought now to descend into oblivion. The signs of the Zodiac and most of the other constellations were invented by the Egyptians or Chaldeans to perpetuate the memory of some of their rude and barbarous heroes, to assist them in their absurd and idolatrous worship,

or to serve the foolish and impious pretensions of astrology. In neither of these respects can the celestial hieroglyphics be interesting or instructive to the modern student of astronomical science; but they are, in almost every point of view, associated with opinions, practices, and representations, which deserve the most marked reprobation: they also distract the attention by turning it aside from the direct objects of the science to the investigation of their fabulous history. How ridiculous the story of Calisto and her son Arcas, whom the rage of Juno turned into bears, which now circulate about the North Pole? the story of Medusa, whose golden hair Minerva turned into snakes, and of the winged horse which sprung from the blood which gushed out in striking off Medusa's head? the story of Orion, who was produced from the hide of an ox moistened with wine? the story of the Dragon which guarded the golden apples in the garden of the Hesperides, and was taken up to heaven and made a constellation on account of his faithful services? the story of Andromeda, of the Swan, of Perseus, and a hundred others of a similar description?

Such is the heaven of the pagans: a common receptacle of all ranks of creatures, real and imaginary, without distinction or order; a wild miscellany of everything that is false, grotesque, and chimerical. Such fantastical groups, which occupy the "houses of the Zodiac" and other compartments of the sky, may comport with the degrading arts of the astrologer, but they are not only incompetent to the purposes, but completely repugnant to the noble elevation of modern astronomical science. How incongruous, then, is it that such representations, the wildest hallucinations of the human mind, should be blazoned in such brilliant colours upon our globes, and that a considerable portion of our astronomical treatises should be occupied in detailing their mythological history? Because a few shepherds in the plains of Babylon or on the banks of the Nile arranged and delineated the heavens according to the first crude conceptions which arose in their minds, are these chimerical representations to guide the astronomers of every nation, and throughout all succeeding generations? It becomes the astronomers of the present day to consider whether they intend to transmit to the enlightened generations of the twentieth or thirtieth century the sublime discoveries of modern times, which have transformed the heavens into an immense assemblage of suns and worlds, in-

corporated and disfigured with hydras, gorgons, flying horses, three-headed dogs, and other "dire chimeras;" or whether they might not be as well qualified as the shepherds of Chaldea to reduce the starry groups, in the concave of the firmament, to a more natural, simple, and scientific arrangement.

4. The constellations, as presently depicted on our globes and planispheres, convey an *unnatural* and complex representation of the heavens, which tends to confuse the imagination of the juvenile student. On some celestial globes which I have inspected, the natural and hieroglyphic figures are so prominently engraved, and the colours with which they are bespattered so deep and vivid, that the stars appeared not only as a secondary object, but were almost invisible, except on a very minute inspection. The animals were so nicely drawn, and exhibited such a glare of variegated colours, that the sphere appeared more like a young miss's plaything than a delineation of the starry heavens. It seemed as if the engraver had been afraid lest his pretty little dogs, and serpents, and scorpions, and flying horses, and crabs, and lizards, should have been disfigured by the radiated groups of stars which spotted the pretty creatures, and therefore he threw them into the shade, in order that the artificial globe, which a late philosopher calls "a philosophical toy," might prove nothing more to the fair one who occasionally twirled it round its axis than a beautifully coloured ball to fill up a niche in her parlour or bedroom. The same thing appears in many of our planispheres of the heavens, on the first opening of which one would imagine he was about to inspect the figures connected with the natural history of animals, or the fantastical representations illustrative of the system of pagan mythology. Whatever may be said of the utility of such delineations, it is evident they present a very awkward and *unnatural* representation of the beautiful and variegated scenery of a starry sky; and hence it is that a young person who wishes to acquire a general knowledge of the positions of the principal stars finds it extremely difficult to recognise them by our present maps and planispheres, on account of their being so much interwoven with extraneous objects, and, on this account, presenting an appearance so very different from what they do in the heavens.

For these and many other reasons, it appears expedient that some change or modification should be adopted in the as-

rangement and delineation of the celestial orbs. Were any scheme of this kind attempted, it would be proper to proceed on the following principle, among others, namely, *to give names to the starry groups from objects which bear the nearest resemblance to the actual figures which appear in the heavens.* I shall not presume at present to determine what are the particular objects which might be selected for representing the constellations, as it would require a combination of astronomers to enter particularly into the discussion. It is evident, however, that a number of clusters might be reduced to mathematical figures and diagrams; and in so far as these were found to resemble the starry groups, they would form a *natural* representation. For there actually appear in the heavens, triangles, squares, parallelograms, pentagons, crosses, trapeziums, perpendicular and parallel lines, and various combinations of geometrical schemes, some of which might be selected for the purpose proposed. It would be expedient that as many as possible of the old constellations should be preserved entire, such as Orion, Ursa Major, and others; and that those which behooved to be somewhat deranged should be so divided as that two or more of the new-formed constellations should exactly correspond to one of the old, and *vice versa.*

To any proposal of this kind, however, I am aware that many objections would be raised, particularly that it would introduce confusion into the science of astronomy, especially when references are made to ancient catalogues and observations. It is well known, however, that a similar difficulty has been overcome in reference to the science of *chymistry.* The new nomenclature, which was intended to express the *nature* of the substance by the *name* which is attached to it, though at first scouted by many eminent chymists and philosophers, is now universally adopted, and has introduced both simplicity and precision into the science. The same may be said of the departments of geology, botany, zoology, mineralogy, and meteorology. The principle now proposed in reference to the constellations is materially the same as that which led to the adoption of a new chymical nomenclature; and, with regard to the inconveniences attending a new set of terms, it may be observed, in the words of M. Bergman, that "those who are already possessed of knowledge cannot be deprived of it by new terms; and those who have their knowl-

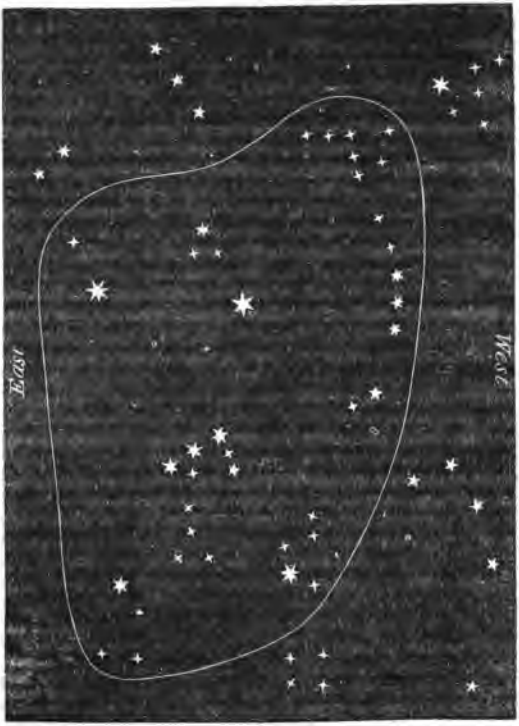
edge to acquire will be enabled, by an improvement in the language of the science, to acquire it sooner."

The opposition, however, which is generally made to every innovation, whether in science or in religion, the high respect in which everything is held which has the sanction of antiquity, and the difficulty of forming such an arrangement as would combine simplicity with accuracy, and meet the approbation of astronomers, will probably postpone the attempt to some distant period. I would therefore propose, in the mean time, as matters now stand, one or other of the following plans for adoption: 1. That the stars be depicted on celestial globes and planispheres in their true positions and apparent magnitudes, without being connected with any hieroglyphic delineations; the different constellations still retaining their former names. By this plan, the different clusters, not being encumbered and buried, as it were, in a medley of grotesque and extraneous representations, would appear in their natural simplicity, without distortion and confusion, so that the globe, being rectified to any particular position of the heavens, would appear a *natural* as well as an accurate representation of the corresponding orbs of the firmament. To distinguish the boundaries of the constellations, a dotted line might be drawn around them, and each of them receive a slight tint of colouring, so that their shape and limits may be distinguished at a glance. Or, 2. Instead of engraving the stars on a white ground, as is always done on the globes, let them be engraved on a black or a dark blue ground, so that the several stars may appear as so many white specks, varying in size according to their apparent magnitudes, with a white border (which might be coloured if deemed expedient) around each constellation, to mark its boundaries. On this plan the principal stars in the constellation *Orion*, with its boundary, would appear nearly as represented in the following page.

This mode of delineation would exhibit the most *natural* representation which can be made, on a convex surface, of the appearance of the starry sky. I am fully persuaded that globes, with either of these modes of delineation, particularly the last, would be prized by a numerous class of individuals; as I have seldom conversed with any persons on this subject who would not have preferred such a simple and natural delineation to those which are bespattered with the mythological figures. Should it, however, be deemed necessary, in cases

Fig. 4.

North.



of particular and minute reference, to have globes and planispheres on the common plan, a number of delineations of both kinds might be engraved to suit the taste of different individuals; and those to whom money is no great object

would furnish themselves with one of each description; so that the one globe would prove a mutual assistance to the other.*

That the opinions I have now expressed on this subject are not altogether singular, will appear from the following extract from Sir J. Herschel's "Astronomy," p. 162. "Of course we do not here speak of those uncouth figures, and outlines of men and monsters, which are usually scribbled over celestial globes and maps, in a rude and barbarous way, to enable us to talk of groups of stars or districts in the heavens, by names which, though absurd or puerile in their origin, it would be difficult to dislodge them. In so far as they have really any slight resemblance to the figures called up in imagination by a view of the more splendid 'constellations,' they have a certain convenience; but as they are otherwise entirely arbitrary, and correspond to no *natural* subdivisions or groupings of the stars, astronomers treat them lightly, or altogether disregard them, except for briefly naming particular stars, as *α* Leonis, *β* Scorpio, &c., by letters of the Greek alphabet attached to them." And again: "This disregard is neither supercilious nor causeless. The constellations seem to have been almost purposely named and delineated to cause as much confusion and inconvenience as possible. Innumerable snakes twine through long and contorted areas of the heavens, where no memory can follow them; bears, lions, and fishes, large and small, northern and southern, confuse all nomenclature, &c. A better system of constellations might have been a material help as an artificial memory."†

* The above remarks are abridged from two papers on this subject, which the author communicated twenty years ago to the London "Monthly Magazine" for October, 1818, and January, 1819, vol. 46, p. 201 and 500.

† Since the above was written, in April, 1838, I am happy to learn that the "British Association for the Advancement of Science" has had its attention directed to this subject. At the meeting at Newcastle in August, 1838, it was resolved, "That it is desirable that a revision of the nomenclature of the stars should be made, with a view to ascertain whether or not a more correct distribution of them among the present constellations, or such other constellations as it may be considered desirable to adopt, may be formed." At the meeting at Birmingham, August, 1839, the committee appointed to report on this subject stated, "That some progress has been made in reforming the nomenclature of the northern constellations; and that the stars in the southern have been commenced laying down on a planisphere, according to their observed actual magnitudes, for the purpose of grouping them in a more convenient and

CHAPTER IV.

ON THE DISTANCES OF THE STARS.

To measure the length and breadth of an extensive kingdom, and to compute its dimensions, or to determine the distances between two large islands or continents, was formerly reckoned an achievement of considerable magnitude; but to measure the whole earth, to compute its area, and to determine its exact figure and magnitude, were considered as the most astonishing enterprises ever attempted by man, and almost beyond the reach of the powers with which he is endowed. Confined to a small spot in the world in which he dwells, having no scale of measurement, in the first instance, but his own dimensions, or the length of a rod or chain formed from these dimensions, how can he measure spaces hundreds of times greater than the extent of his whole visible horizon? how can he compute the distances and dimensions of places which he has never visited, and some of which he never can visit, and embrace the whole amplitude of a world which has never been thoroughly explored? The height of his body is but a fathom, and the length of his chain but a score of fathoms; and such measures dwindle into mere points when compared with the dimensions of the earth. Hence it happened that many ages elapsed before the figure and dimensions of the world in which we dwell were nearly ascertained. The powers of the human mind, however, when called into action and properly exercised, are not only capable of such enterprises, but adequate to the performance of still more elevated achievements. When the mind of man is determined on the pursuit of knowledge, and bent upon improvement, difficulties, however great, only serve as incitements to action and perseverance, and to stimulate his energies to their highest pitch

advantageous manner." It is hoped, therefore, that we shall soon be presented with an arrangement and nomenclature of the starry groups accordant with the sublime conceptions and discoveries of modern astronomy, and which shall present, on our globes and planispheres, a more perspicuous and natural representation of the heavens.

of exertion. He multiplies small measures till he arrive at greater; he combines units into tens, tens into hundreds, hundreds into thousands, and thousands into millions. He combines lines into angles, angles into triangles; compares triangles, squares, and circles together; ascertains their peculiar properties and relations; and, from the conclusions he deduces, constructs instruments and ascertains principles which enable him not only to measure the dimensions of this lower world, but the magnitudes and distances of the globes which roll around him in the heavens.

There is no saying at what point the human faculties will stop when once they are aroused to active operation, and stimulated to exert all their energies. We have not only ascertained the bulk of the terraqueous globe, its spheroidal figure, its diurnal and annual motions, and the relation in which it stands to other bodies in the universe, but we have determined the dimensions of the solar system, and the distances and magnitudes of most of the bodies it contains, so that we can now speak with as much certainty of the distance of the sun, or of Jupiter and Saturn, as we can of the distance of London from Paris, or of the distances of any two places on the surface of the earth. This is an achievement which at first view might have appeared beyond the power of human genius to accomplish; but by the unwearied observations of modern astronomers, and the application of mathematical principles to such observations, they have been enabled to trace the exact movements of the machinery which is in operation around us, and to determine with precision the relative distance and position of every planet within the system of the sun. There are limits, however, beyond which it is difficult for the human faculties to penetrate. The planetary system comprises an area so vast that imagination is almost lost in the conception. A circle drawn around its circumference would measure more than eleven thousand millions of miles; and a body moving at the rate of thirty miles an hour would require above forty-two thousand years to complete the circuit; still these vast dimensions are within the limits of measurable distance. But when we attempt to pass beyond the boundaries of this system into the illimitable spaces which lie beyond, all our usual modes of computation begin to fail, and the mind is overpowered and bewildered amid boundless space, and the multiplicity of orbs which fill the regions of

immensity. We can tell that some of the nearest of these orbs are not within a certain distance, but how far they may lie beyond it the most expert astronomer has never yet been able to compute.

The principal mode by which the distance of the fixed stars has been attempted to be determined, is by endeavouring to ascertain whether any of them have an *annual parallax*. I have already explained the mode by which the distances ot the sun, moon, and planets is determined by means of the *horizontal parallax*, or the angle under which the earth's semidiameter is seen at any of these bodies.* But such a mode is altogether inapplicable to the fixed stars, whose distance from the earth is so great that the horizontal parallax is quite imperceptible. Astronomers have therefore attempted to find a parallax by using the whole diameter of the earth's annual orbit as a *base line*, namely, one hundred and ninety millions of miles, and endeavouring to ascertain whether any of the fixed stars appear to shift their position when viewed from the opposite extremities of this line. The nature and mode of this investigation will appear from the following explanations:

The axis of the earth extended, being carried parallel to itself during its annual revolution round the sun, describes a circle in the sphere of the fixed stars equal to the orbit of the earth. Thus (fig. 5), let *A B C D* be the orbit of the earth, *S* the sun, the dotted lines the axis of the earth extended; this axis, when the earth is at *A*, points at *a* in the sphere of the heavens; when the earth is at *B*, it points at *b*; when at *C*, it points at *c*; and when at *D*, it points at *d*; so that in the course of a year it describes the circle *a b c d* in the sphere of the heavens, equal to the circle *A B C D*. But although the orbit of the earth, and, consequently, the circle *a b c d*, be immensely large, no less than many millions of miles in diameter, yet it is but a point in comparison of the boundless sphere of the heavens. The angle under which it appears to an inhabitant of the earth is insensible by any instruments or observations that have hitherto been made, and therefore the celestial poles appear in the same points of the heavens during the whole of the earth's annual course. The star *H* is nearer the point *a* than it is to the point *c* by the whole length of the

* "Celestial Scenery," p. 309-329.

line *a c*; yet if this line *a c*, great as it is when viewed from the earth, should occupy no *sensible* space in the sphere of the

Fig. 5.

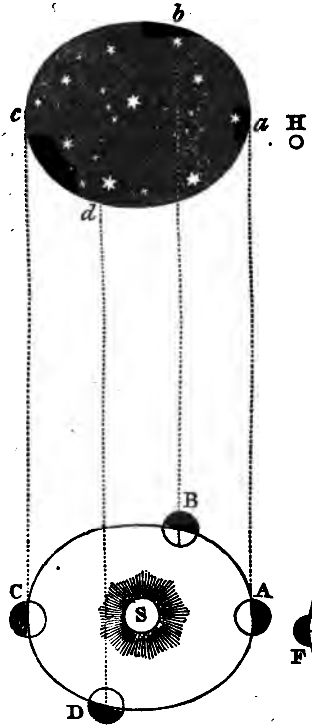
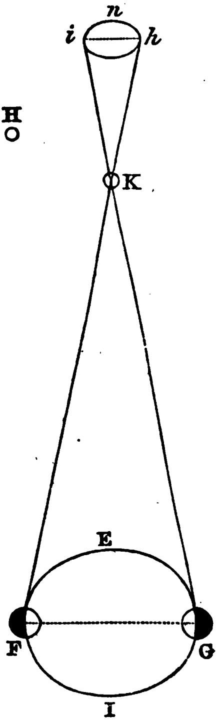


Fig. 6.



heavens, the star will appear at the same distance from the pole throughout every portion of the annual revolution, and

consequently, will have no parallax, which is found to be the fact.

If the annual parallax of a fixed star were sensible, the star would appear to change its place so as to describe a small ellipsis in the sphere of the heavens in the course of a year, or an annual revolution of the earth. Thus, let $G\ E\ F\ I$ (fig. 6) be the orbit of the earth, and K the star to be observed, if we imagine a straight line to be drawn from the earth at G through the star to a point in the heavens, as at i, that visual line $G\ i$ being carried along with the earth in its annual motion, will describe the ellipse $h\ n\ i$; in other words, the motion of the earth round its orbit $G\ E\ F\ I$ will make the star appear to go round the ellipse $h\ n\ i$. If the star K were in the pole of the ecliptic, the ellipse it described would have the same eccentricity as the orbit of the earth, and, consequently, would differ very little from a circle; if it were at any distance from the pole of the ecliptic,* the greater that distance, the more oblong would be the ellipse. If the star were in the plane of the ecliptic, the ellipse would become a straight line, as $i\ h$, in which the star would appear to move one half of the year according to the order of the signs, and contrary to the order of the signs during the other half, somewhat similar to the appearance which the moons of Jupiter present when moving between the opposite points of their orbits. If, therefore, the stars were at a moderate distance from the earth, so that the diameter of the earth's orbit, $G\ F$, bore a sensible proportion to that distance, the star would be found at one time of the year, suppose the month of December, at the point i, and at the opposite season, in the month of June, at the point h; and if the angle $i\ K\ h$, which is equal to the angle $G\ K\ F$, could be found, it would constitute what is termed the *annual parallax*; and having obtained this parallax, and knowing the extent of the base line $G\ F$, or the diameter of the earth's orbit, the distance of the stars whose parallax was ascertained could then be determined by an easy process in trigonometry; for as radius : is to the sine of the angle $i\ K\ h = G\ K\ F$: : so is the diameter of the orbit of the

* The *pole* of the ecliptic is that point in the heavens which is farthest distant from the plane of the earth's orbit, or 90° from every part of it, as the north pole of the earth is the point distant 90° from the equator. The pole of *any circle* is a point on the surface of the sphere 90° distant from every part of that circle of which it is the pole.

earth, 190,000,000 of miles : to a fourth number, which would express the distance of the particular stars from our globe.

But this angle, in respect to any of the stars, has never yet been ascertained, although astronomers for more than a century past have used the most accurate instruments which ingenuity could contrive, and the most unwearied observations in order to determine it.

Galileo appears to have been the first who thought of trying whether the annual parallax of the stars were discoverable. Taking for granted that the stars are placed at different distances from the earth, and that those stars which are nearest will appear the largest, he suggested that, by observing with a telescope two stars very near each other, one of the greatest and the other of the least magnitude, their apparent distance from each other might perhaps be found to vary as they were viewed from different parts of the earth's orbit at different times of the year; but no change of position whatever was at that period perceived.

If any change of this kind were perceptible, it behooved to be a change either in the longitude or latitude of the stars fixed upon as the subject of observation. These are found, not directly, but by first determining their declination and right ascension. The declination of a star is found by taking its meridian altitude and subtracting the height of the equator; the right ascension is found by the time of its coming to the meridian.* We have thus two methods pointed out of attempting to determine the annual parallax of the stars: *one* by observing if any change can be discovered in the meridian altitudes of the same star at different times of the year; the *other* by examining whether the intervals of time between any two stars coming to the meridian are equal throughout the year. If there be any sensible change of declination in any of the stars, it must be greatest in those which are near

* The *latitude* of a star is its distance from the *ecliptic*, either north or south, counted towards the pole of the ecliptic. Its *longitude* is its distance from the first point of Aries, reckoned eastward on the *ecliptic*. The declination of a star is its distance from the *equinoctial*, north or south, and the greatest declination it can have is 90°. Its *right ascension* is its distance from the first point of Aries, reckoned on the *equinoctial* eastward round the sphere of the heavens, or that degree of the equinoctial which comes to the meridian with the star. By the right ascension and declination the situation of stars in the heavens is determined, as that of places on the earth by longitude and latitude.

the pole of the ecliptic; but the change of right ascension must be greatest in stars in the solstitial colure, and nearest the pole of the equinoctial.

The following is the plan by which the discovery of the annual parallax, by the *change of declination* of the stars, may be attempted. Let a telescope be placed perpendicularly to the horizon, and through this instrument, when accurately adjusted, observe some star in or near the solstitial colure,* which passes through the zenith, or very near it. If the parallax of the star be sensible, there will appear a difference in its altitudes at different periods of the year, and its altitudes at the two solstices† will differ most from each other. In the month of *June*, a star that passes through the zenith of any place, in north latitude, will in *December* pass *south* of the zenith; and a star that in December passes through the zenith, will in June pass to the north of it, if there be any sensible parallax.

The celebrated Dr. Robert Hook was among the first who suggested this method of attempting to find the parallax of the stars. In the year 1669 he endeavoured to put it in practice at Gresham College, with a telescope thirty-six feet in length. His first observation was made on the 6th of July, on the bright star in the head of *Draco* marked *Gamma*. On that day it passed 2′ 12″ north of the zenith. On July 9th it passed at the same distance as before. On the 6th of August the star passed north of the zenith 2′ 6″, and on the 21st of October it passed 1′ 48″ north of the zenith. But at that period astronomical instruments were not constructed with such accuracy as to enable the observer to determine with precision the quantity of so small angles; and even Dr. Hook himself could place no great reliance on such observations. In the year 1689, Flamstead, the astronomer royal, commenced similar observations with an instrument adapted to a refracting telescope seven feet long, and, after numerous observations, he supposed that he found the Pole-star nearer the pole in De-

* The *colures* are two great circles passing through the poles of the world; one of them passes through the equinoctial points Aries and Libra, which is called the *equinoctial colure;* the other through the solstitial points Cancer and Capricorn, called the *solstitial colure.* They are drawn on all celestial globes and planispheres.

† The *solstitial* points, or solstices, are where the ecliptic touches the first points of Cancer and Capricorn. The summer solstice is on the 21st of June; the winter solstice is on the 21st of December.

cember than in the months of April, May, July, August, or September; and that its apparent distance from the pole was greater in April than in September, and greater in July and May than in April; and from the whole of his observations he deduced that its apparent distance from the pole in June must be forty-six seconds different from that in December. But even Flamstead himself speaks of these observations with a great deal of diffidence, owing to his doubts about the regular divisions of his instruments.

From these observations of Hook and Flamstead, supposing them to be nearly correct, Mr. Whiston computed that the greatest annual parallax of a star in the pole of the ecliptic is forty-seven seconds; and hence he calculated the distance of such stars to be about 9000 *semidiameters* of the earth's orbit, then estimated at eighty millions of miles, or about 700,000,000,000, that is, seven hundred thousand millions of miles; a distance so great that it would require a cannon ball, moving 500 miles an hour, more than 160,000 years to move across this immense interval. But we have reason to believe that the distance of the nearest stars from our globe is at least forty times the distance now stated; for modern astronomers would long since have determined the annual parallax had it been nearly so great as Hook and Flamstead supposed; nay, had it amounted to 2″ instead of 47″, this grand problem, as it respects the nearest stars, would have been resolved.

The human mind, when ardently engaged in the pursuit of any object, is seldom deterred by difficulties; and astronomers in particular, notwithstanding the intricacies and difficulties connected with many of the objects of their investigation, have persevered in their observations and researches, and have not unfrequently arrived at the most important and unexpected results. In the year 1725, Mr. Molyneux, doubtful of the accuracy of the observations of Hook and Flamstead, began a series of observations, to ascertain, if possible, the true annual parallax. Assisted by Dr. Bradley, he placed a telescope of twenty-four feet long perpendicularly at his house at Kew, and began to observe the same bright star in Draco as Hook had done. From the 3d of December that year it was found that the star did not sensibly change its distance from the zenith for several days. On December 17th it passed a little more southerly, and continued gradually to pass

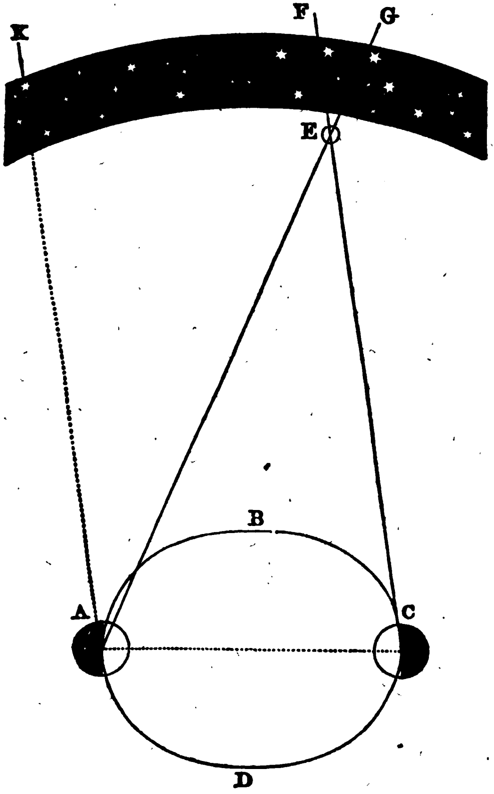
more and more southerly at every transit over the meridian till the beginning of March, when it was found to pass twenty seconds more southerly than at the time of the first observation. About the middle of April it appeared to be returning towards the north, and at the beginning of June it passed the meridian at the same distance from the zenith as in December, when it was first observed. From that time it appeared more and more northerly at every transit till September following, being then near twenty seconds more northerly than in June, and no less than thirty-nine seconds more *northerly* than in March. From September the star returned towards the south, till it arrived, in December, at the same situation in which it was found a twelvemonth before.

The result of these observations, so different from what was expected, was a matter of great surprise to the observers; for it appeared that the star was thirty-nine seconds more northerly in September than in March, *just the contrary to what it ought to appear by the annual parallax of the stars*. This may be illustrated by the opposite figure:

Let *A B C D* represent the orbit of the earth, and *A* and *C* the place of the earth at two opposite periods of the year; then a fixed object at *E* will be seen from the earth at *A*, in the line *A E*, which will point out its apparent place at *G* in the concave expanse of the sky. But at the opposite period of the year it will be seen from the earth at *C*, in the line *C E*, which will project its place in the heavens at *F*; so that, while the earth has passed from *A* to *C*, the object will appear to have moved from *G* to *F*, through the space *G F*, provided there be any sensible parallax. Now, in the case of the observations stated above, the observers who in *September* saw the star at *F*, did in *March* following observe it at *K*, in the right line *A K*, parallel to *C F*, and not at *G*, where it ought to have appeared by the parallactic motion; so that, instead of finding a parallax, they found a result directly opposite to what they expected, which exceedingly perplexed the observers, and one of them, Mr. Molyneux, died before the true cause of it was discovered.

Some time afterward, Dr. Bradley repeated the same observations with an instrument of great accuracy, to which was appended a telescope twelve and a half feet long. With this instrument, which was so nicely adjusted that he could depend upon it even to half a second, he continued his observa-

Fig. 7.



tions for more than two years, not only on the bright star in Draco above alluded to, but on many other stars, and always

observed the same appearances and arrived at the same results. At last, after many reflections and conjectures on the subject, he arrived at the following conclusion, namely, that the phenomena he had observed was owing to "the progressive motion of light, and the sensible proportion which its velocity bears to the velocity of the annual motion of the earth." In other words, that *the motion of light, combined with the progressive motion of the earth in its orbit, causes the stars to be seen in a different position, from what they would be if the eye were at rest.* This position, after it was explained and demonstrated, was considered as one of the most brilliant discoveries which had been brought to light during the last century. It agrees with the velocity of light which had been deduced from the eclipses of Jupiter's satellites, and it amounts to a *sensible* demonstration of the *annual* motion of the earth. The observations which led to this discovery likewise prove the immense distance of the stars from the earth; for Dr. Bradley assures us, from the accuracy with which they were conducted, that if the annual parallax had amounted to so much as *one second*, he should have discovered it.

If, then, the greatest annual parallax of the nearest stars does not amount to one second, their distance must be immense. Supposing the parallax to be exactly one second, the distance of a star having this parallax will be found by the following trigonometrical proportion: As the sine of 1″ : is to radius : : so is the semidiameter of the earth's orbit : to a fourth number, which expresses the distance of the star. Now a parallax of one second determines the object to be 212,000 times farther from the earth than is the sun. The distance of the sun is 95,000,000 of miles, which, multiplied by 212,000, produces 20,140,000,000,000, or more than *twenty billions* of miles. This distance is absolutely certain: it follows, as a matter of course, if the annual parallax were determined to be one second. It is the *very least distance* at which any of the fixed stars can be situated from our globe; but as the parallax does not amount to this quantity, their distance must be much farther than what is here stated, perhaps not less than double or treble that distance. We may acquire some faint idea of the immense distance stated above by considering that a cannon ball, flying with uniform velocity 500 miles every hour, would require *four millions, and five hundred and ninety-five thousand years* before it could reach an

object at the distance we have stated. Such are the ample and inconceivable dimensions of the spaces of the universe.

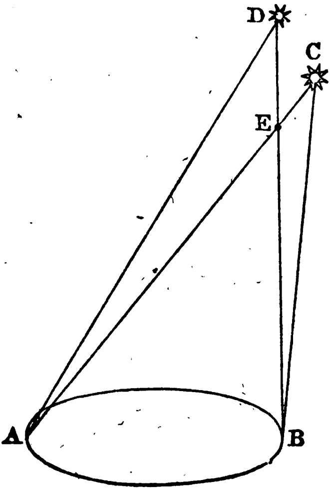
Several other methods have been resorted to by astronomers, in order, if possible, to determine the distance of the stars, but most of them are founded upon assumptions which have not yet been proved. The celebrated Huygens, as recorded in his "Cosmotheoros," despairing of being able to find an annual parallax, resorted to the following method: supposing that the star *Sirius*, one of the brightest fixed stars in the heavens, to be equal in lustre and magnitude to the sun, he endeavoured to diminish the apparent diameter of the sun to the eye, so that it should appear no larger or brighter than Sirius appears to a common observer. For this purpose he closed one end of a twelve feet tube with a very thin plate, in the middle of which he made so small a hole, that a very minute glass globule being put into it, so very small did the sun appear to the eye placed at the other end of the tube, that the light transmitted to the eye seemed not more splendid than that which we behold transmitted from Sirius with the naked eye. Having calculated, on the principles of optics, the quantity of diminution of the sun's apparent diameter, he found it to be only the 1·27664th part; or, the light and diameter of the sun appeared 27,664 times smaller than what we daily see. Hence he concluded that, were the sun at 27,664 times his present distance from us, he would appear as small as Sirius; and, consequently, if Sirius be of the same magnitude as the sun, the distance of that star must be 27,664 times greater than the distance of the sun from the earth, or 2.628,080,-000,000; that is, two billions, six hundred and twenty-eight thousand and eighty millions of miles. This method of determining the distance of the stars depends upon two assumptions: 1st, that the sun and Sirius are equal in magnitude; and, 2d, that the eye judged correctly of the equality of the small intercepted portion of the sun to Sirius; both of which must be considered as uncertain. But it corroborates the general position of the very great distance of the stars.

On a principle somewhat similar, but by experiments conducted with far greater accuracy, Dr. Wollaston endeavoured to determine the same problem in relation to the stars. "This gentleman," Sir J. Herschel remarks, "by direct photometrical experiments, open, as it would seem, to no objections, has ascertained the light of Sirius, as received by us, to be to that

of the sun as 1 to 20,000,000,000. The sun, therefore, in order that it should appear to us no brighter than Sirius, would require to be removed to 141,400 times its actual distance. We have seen, however, that the distance of Sirius cannot be so small as 200,000 times that of the sun. Hence it follows that, upon the lowest possible computation, the light really thrown out by Sirius cannot be so little as *double* that emitted by the sun; or that Sirius must, in point of intrinsic splendour, be at least equal to *two suns*, and is, in all probability, vastly greater."

The late Sir William Herschel proposed another method of determining the annual parallax by means of *double stars*, which he supposed would be free from the errors of other methods, and of such a nature that the parallax, even if it should not exceed the tenth part of a second, may still become visible. The following figure and description will convey a general idea of this method:

Fig. 8.



Let *A* and *B* (fig. 8) represent the earth at two opposite points in its orbit, and *C* and *D* two stars of different magnitudes. Then, if when the earth is at *B*, the two stars appear to us near each other, as at *C* and *E*, it was thought that when the earth arrived at *A* the two stars might appear farther apart, as at *C* and *D*; in other words, that the angles at which they would appear to us in the two cases would be different, the angle *D A C* being larger than the angle *D B C*, in which case the angle of parallax might be computed. But it does not appear that any difference in the angles referred to has yet been found, or that any definite conclusions respecting parallax have hitherto been deduced from this method, excepting the general position that the stars are at too great a distance to be subjected to our calculations, or that our angular instruments are still in too imperfect a state to detect so small an angle as that of the annual parallax.

While writing the above (December, 1838), I perceived an announcement in certain literary journals, that Professor Bessel, of Kongisberg, had addressed a letter to Sir John Herschel, which was immediately communicated to the Royal Astronomical Society, containing an account of the discovery of the annual parallax and the observations on which it was founded. In the introduction to this communication Professor Bessel says: "After so many unsuccessful attempts to determine the parallax of a fixed star, I thought it worth while to try what might be accomplished by means of the accuracy which my great Fraunhofer heliometer gives to the observations. I undertook to make this investigation upon the star 61 *Cygni*, which, by reason of its great proper motion, is perhaps the best of all, which affords the advantage of being a double star, and on that account may be observed with greater accuracy, and which is so near the pole that, with the exception of a small part of the year, it can always be observed at night at a sufficient distance from the horizon." The professor began his observations in September, 1834, but various circumstances prevented them from being regularly continued at that period. They were resumed in 1837 with certain hopes of success. He selected among the small stars which surround the double star 61 *Cygni* two stars between the ninth and tenth magnitudes, of which one (*a*) is nearly perpendicular to the line of direction of the double star, the other (*b*) nearly in this direction. He measured with the heliome-

ter the distances of these stars from the point which bisects the distance between the two stars of 61 Cygni, and generally repeated the observations sixteen times every night, and when the atmosphere was unusually steady he made more numerous repetitions. The places of both stars, referred to the middle point of the double star, he calculated, for the beginning of 1838, to be,

	Distance.	Angle of Position.
a	461″.617	201° 29′ 24″
b	706″.279	109° 22′ 10″

In these observations he concentrated his attention as far as he could on the *distance* of the small stars from the double star, as being the most important point to be ascertained. His communication contains tables of all his measures of distance, freed from the effects of refraction and aberration, and reduced to the beginning of 1838.

It would be uninteresting to the general reader to enter into all the details of observations, corrections, and calculations which Professor Bessel's communication contains, as they can only be understood by practical astronomers. I shall therefore only state his general conclusion, which seems to be legitimately deduced from his observations and reasonings, and may be considered at least as a very near approximation to the point, if not perfectly correct. The result then is, that the annual parallax of the star 61 *Cygni* is 0″.3136; that is, somewhat less than *one third of a second.* It follows that the distance of this star from the sun is 657,700 times the mean distance of the earth from the sun; and as the distance of the sun from the earth is 95,000,000 of miles, this number multiplied by the former produces 62,481,500,000,000, or *sixty-two* BILLIONS, *four hundred and eighty-one thousand five hundred* MILLIONS of miles, which is the distance of the star 61 *Cygni* from the sun, and which, of course, is nearly about the same distance from the earth; the earth being in one part of its course ninety-five millions of miles nearer the star than this distance, and in the opposite part of it ninety-five millions of miles beyond it. This, I have no doubt, will be considered as one of the most interesting and splendid discoveries which have been made in astronomy for a century past. It lays a foundation for precise and definite conceptions of the distances of some of the starry orbs, of the am-

plitude of the celestial regions, and of the magnitude and grandeur of those countless orbs which diversify the spaces of immensity. It likewise proves to a demonstration the annual motion of the earth round the sun, and all the principles and phenomena with which it is connected, as well as corroborates the general views of former astronomers respecting the immense distance of the fixed stars.

Professor Bessel concludes his communication in these words: "As the annual proper motion of *a Cygni* amounts to 5′.123 of a great circle, the *relative* motion of this star and the sun must be considerably more than sixteen semidiameters of the earth's orbit [that is, one thousand five hundred and twenty millions of miles], and the star must have a constant aberration of more than 52″. When we shall have succeeded in determining the elements of the motion of both the stars forming the double star, round their common centre of gravity, we shall be able to determine the sum of their masses. I have attentively considered the preceding observations of their relative positions, but I consider them as yet very inadequate to afford the elements of the orbit. I consider them as sufficient only to show that the annual angular motion is somewhere about two thirds of a degree, and that the distance at the beginning of this century had a minimum of about 15″. We are enabled hence to conclude that the time of a revolution is more than 540 years, and that the semi-major axis of the orbit is seen under an angle of more than 15″. If, however, we proceed from these numbers, which are merely *limits*, we find the sum of the masses of both stars less than half the sun's mass. But this point, which is deserving of attention, cannot be established till the observations shall be sufficient to determine the elements accurately. When long-continued observations of the places which the double star occupies among the small stars which surround it shall have led to the knowledge of its centre of gravity, we shall be enabled to determine the two masses separately; but we cannot anticipate the time of these farther researches. I have here troubled you with many particulars; but I trust it is not necessary to offer any excuse for this, since a correct opinion as to whether the investigation of the parallax of 61 *Cygni* has already led to an approximate result, or must still be carried farther before this can be affirmed of them, can only be formed from a knowledge of these particulars. Had I merely com-

municated to you the result, I could not have expected that you would attribute to it that *certainty* which, according to my own judgment, it possessed."

The distance inferred from the parallax ascertained by Bessel is more than three times greater than what was formerly considered the *least distance* of any of the fixed stars. In order to acquire some rude conceptions of this distance, it may not be inexpedient to illustrate it by the times which certain moving bodies would require to move along such a space. *Light* is the swiftest moving body with which we are acquainted; it flies from the sun to the earth, a distance of ninety-five million of miles, in about eight minutes, or at the rate of 192.000 miles every moment of time; yet light, incomprehensively swift as its motion is, would require 10 years and 114 days to fly across this mighty interval; so that if the star 61 *Cygni* were supposed to be only just now launched into existence, it would be more than ten years before its light could reach the distant globe on which we dwell, so as to appear like a small star twinkling in our sky. Suppose a cannon ball to move 500 miles every hour without intermission, it would require fourteen millions, two hundred and fifty-five thousand, four hundred and eighteen years before it could move across the same interval. But to come to motions with which we are more familiar: suppose a steam carriage to set out from the earth with a velocity of twenty miles an hour, or 480 miles a day; at this rate of motion, continued without intermission, it would require 356,385,466, or three hundred and fifty-six millions, three hundred and eighty-five thousand, four hundred and sixty-six years before it could pass from our globe to the star alluded to above; a number of years sixty-one thousand times greater than the whole period which has elapsed since the Mosaic creation.

Such distances are amazing, and almost terrifying to the human imagination. The mind is bewildered, confounded, and almost overwhelmed, when attempting to form a conception of such portions of immensity, and feels its own littleness, the limited nature of its powers, and its utter incapacity for grasping the amplitudes of creation; but although it were possible for us to wing our flight to such a distant orb as that to which we have referred, we should still find ourselves standing on the extreme verge of the starry firmament, where ten thousands of other orbs, a thousand times more distant, would

meet our view. We have reason to believe that a space nearly equal to that which we are now considering intervenes between most of the stars which diversify our nocturnal sky. The stars appear of different magnitudes; but we have the strongest reason to conclude that in the majority of instances this is owing, not to the difference of their real magnitudes, but to the different distances at which they are placed from our globe. If, then, the distance of a star of the first or second magnitude, or those which are nearest us, be so immensely great, what must be the distance of stars of the sixteenth or twentieth magnitude, which can be distinguished only by the most powerful telescopes? Some of these must be several thousands of times more distant than the star 61 Cygni, whose distance now appears to be determined. And what shall we think of the distance of those which lie beyond the reach of the most powerful telescopes that have yet been constructed, stretching beyond the utmost limits of mortal vision, within the unexplored regions of immensity? Here even the most vigorous imagination drops its wing, and feels itself utterly unable to penetrate this mysterious and boundless unknown.

The vastness of the spaces and the greatness of the distances to which we have adverted ought not, however, to prevent any one from acquiescing in the statements we have now made; for space is boundless, absolutely infinite. A seraph might wing his flight with the swiftness of light for millions of years through the regions of immensity, and never arrive at a boundary where it might be said, "Hitherto mayest thou approach, but no farther;" and we have reason to believe, from what we already know of the Creator and his works, that during the whole course of such an excursion, new objects and new scenes of glory and magnificence would be continually rising to his view. To suppose otherwise would be to set boundaries to space, and to prescribe limits to the infinite perfections of the Divinity. That incomprehensible Being who formed the universe fills immensity with his presence; his power and wisdom, and all his other perfections, are *infinite*; and therefore we should expect that the plans on which he has constructed the systems of the universe should be like himself, vast, boundless, and inconceivable by mortals. Were we to find the plans of the universe circumscribed like those which were represented by the ancient astronomers, who

imagined the firmament a solid sphere, with a number of tapers whirled round the earth, we should be apt to think that the Creator of the world was a limited being; but when we contemplate the vast amplitude of planetary systems, and the immense spaces by which they are separated from each other, we behold plans and operations which are in perfect unison with the immensity of his nature, with his boundless power, his uncontrollable agency, and his universal presence. Wherever we turn our eyes throughout the scene of nature, and fix our attention on its plans and movements, we uniformly find the Creator *acting like himself*; and in no case is this more strikingly displayed than in the grandeur and magnificence of the orbs of heaven, and *the immense spaces with which they are surrounded*.

This is likewise the representation which the Scriptures give us of the immensity and incomprehensible nature of the Deity. "Great is Jehovah and of great power; his understanding is infinite; his greatness is unsearchable." He is not only "high above all nations," but "his glory is *above the heavens*." "He dwelleth on high, and humbleth himself to behold the things" not only that are "on the earth," but even "the things that are in the heavens." Vast as the celestial spaces are, "he meted out heaven with the span," and "stretched forth the heavens alone." "Among the gods there is none like unto thee, neither are there any works like unto thy works." "Canst thou by searching find out God? Canst thou find out the Almighty to perfection? Who can utter the mighty operations of Jehovah? Who can show forth all his praise? Lo, these are but parts of his ways; but the thunder of his power, or the full extent of his omnipotence, who can comprehend?" In relation to a Being who is thus described, we can expect nothing but what is wonderful, and incomprehensible by finite minds. The declarations of inspired men bear testimony to the discoveries of astronomy as in perfect unison with the attributes of the Divinity, so that science and revelation completely harmonize in the views they unfold of the plans and arrangements of the Deity, and of the immense spaces which intervene among the systems of the universe.

Whether man will ever be permitted to traverse any of the vast spaces of the universe to which we have now adverted, is a question which is at present beyond our province to re-

solve. In our present state of corporeal organization, it is impossible to wing our flight even to the nearest celestial orb in that system of which we form a part, much less to the distant starry regions. How pure spirits, disconnected with material vehicles, may transport themselves from one region of creation to another, it is impossible for us, in the present state, to form a conception. But it is possible to conceive of a system of organization far more refined than the present, and susceptible of a power of motion far surpassing what we have an opportunity of witnessing in this terrestrial sphere; a locomotive power, which might enable an intelligent agent to keep pace with the rapid motions of the celestial orbs. We have only to suppose organical vehicles, constructed with matter far more subtle and refined than hydrogen gas or the ethereal fluid, and approximating to the tenacity of light itself. As we find animalculæ many thousands of times less than the least visible point, their bodies must be constructed of materials extremely subtile and refined; and hence we may infer that the same All-wise Intelligence, who formed such minute and refined structures, can with equal ease construct a material organization for the residence of a rational soul out of the finest materials which creation can supply, and endow it with a capacity of rapid motion superior to that of some of the celestial globes which roll around us. It is not improbable that angelic beings are connected with such a system of material organization, which enables them to move with rapidity from one part of creation to another; and it is possible that man, in a future world, may be invested with such vehicles and such powers of rapid motion. At the same time, even with such locomotive powers, only a small portion of the universe could be supposed to be visited or explored, even after a lapse of ages. It is highly probable that, at this moment, there is not a single subordinate intelligence, even of the highest order of created beings, who is acquainted with every region of universal nature and the objects it contains, and that the greater part of the vast universe, with its scenery, movements, and inhabitants, is known only by Him who formed it by his power and fills it with his presence.

CHAPTER V.

ON THE MAGNITUDE OF THE STARS.

In our attempts to ascertain the *magnitudes* of any of the heavenly bodies, we must first endeavour to determine the distances at which they are placed from our abode; and, in the next place, we must measure, as accurately as possible, the *apparent diameters* of the bodies whose magnitude we wish to determine. The extreme difficulty of determining these two points, in certain instances, on account of the smallness of the angles which require to be measured, has hitherto prevented us from ascertaining with precision the real magnitudes of the bodies connected with the sidereal heavens. We formerly were led to conclude, on good grounds, that their distances were almost immeasurably great, and, consequently, that, as they emit a certain degree of splendour to our eye, even from such remote distances, their *bulk* must be immensely great. But no precise conceptions could be formed as to this point so long as the annual parallax of some of the stars remained undetermined.

The annual parallax of the star 61 *Cygni* being now in all probability ascertained (as stated in the preceding chapter), we are in possession of cartain *data* which may lead to the determination of the *real magnitude* of that body. But a difficulty still remains. The stars are found to have no sensible diameters. When viewed through telescopes of the greatest power, they present no visible disks or well-defined surfaces to the eye, as the planets do when viewed through such instruments, but appear only as so many shining and undefined points. When they are viewed through a telescope of moderate size, their diameters appear less than when examined by the naked eye, but considerably more brilliant. When we view them with a telescope of great power, the apparent diameters will be somewhat increased, but not according to any regular proportion, as happens in the case of the planets; and even when seen with the same power, through different telescopes, their apparent magnitudes are

not precisely the same. Sir William Herschel, who viewed these bodies under almost every aspect, uniformly found that their diameter was less in proportion as the higher powers were applied; and the smallest proportional diameter he ever obtained was when he employed the extraordinary power of 6450 times. From such observations it appears that the apparent diameters of the fixed stars do not arise from any sensible disk, but from other causes with which we are not acquainted. Dr. Halley remarks that "the diameters of Spica Virginis and Aldebaran (two stars of the first magnitude) are so small, that when they happen to immerge behind the dark edge of the moon, they are so far from losing their light gradually, as they must do if they were of any sensible magnitude, that they vanish at once with all their lustre, and emerge likewise in a moment, not small at first, but at once appear with their full light, even although the emersion happen when very near the cusp, where, if they were four seconds in diameter, they would be many seconds of time in getting entirely separated from the limb. But the contrary appears to all those who have observed the occultations of those bright stars." Every one who has been in the habit of viewing the starry firmament with good telescopes will at once admit that, although that instrument brings to view numerous stars which the unassisted sight cannot perceive, yet they appear only as luminous points with no well-defined sensible diameters, although their light is much more brilliant than to the naked eye.

Hence the difficulty of determining, with precision, the real magnitudes of any of the fixed stars. From their immense distance we are perfectly certain that they are bodies of immense size, otherwise they would be altogether invisible from our terrestrial sphere, or from any part of the solar system. But we have hitherto obtained no sufficient data for estimating their exact size, as we have done in relation to the globes which compose the planetary system. Since, then, the apparent diameters of the stars, even those of the *first* magnitude, are so small as not to amount to a single second, we cannot hope, in the mean time, to determine their measure with any degree of certainty. We may assign them a measure which we certainly know they do not exceed, but we cannot be sure that that measure is not too great. All luminous objects appear larger than those of the same dimensions which are opaque. The planet Mercury, when in its greatest

brightness, appears larger than when it is seen to pass, like a dark spot, across the disk of the sun, although it is nearest the earth in this last position. The apparent diameters of the fixed stars are much smaller than they have generally been supposed by those who have attempted to measure them. Yet, small as they are, their real magnitudes must be *very great*, since they are visible to our sight at the immense distance at which they are placed. In proportion to the greatness of their distance and the smallness of their apparent diameters will be their real magnitudes. If we suppose the apparent diameters of any of the stars observed by Dr. Bradley to be equal to the 400,000th part of the sun's apparent diameter, or 1-200th of a second—which is a probable supposition for a star of the second magnitude—it will follow that such a star is equal to the sun in magnitude. For, if the sun were removed to the distance at which such a star is situated, he would appear no larger than those twinkling points, nay, would perhaps disappear altogether from our view. From all the observations and reasonings that have been entered into on this subject, we have no proofs that any of the stars are less than the sun, but it is more probable that many of them equal and even far surpass that luminary in their real dimensions and splendour. Having obtained the parallax of 61 *Cygni*,* if we could find the exact apparent diameter of that star, its real bulk could be calculated with as much ease and certainty as the bulk of the sun, or moon, or any of the planets. But as this important element in the calculation is still a *desideratum*, we must resort to other methods by which we may arrive at the nearest approximation to the truth.

I have already alluded to the photometrical experiments of Dr. Wollaston, in relation to the comparative quantity of light emitted to our eye from the star Sirius and from the sun. In reference to these experiments, Sir John Herschel, in a marginal note, remarks: "Dr. Wollaston assuming, as we think he is perfectly justified in doing, a much lower limit of *possible* parallax in Sirius than we have adopted in the text, has con-

* This star belongs to the constellation *Cygnus*, or the Swan. Its right ascension for January 1, 1839, was 20h 59′ 41″, and its declination 37° 57′ 42″ north. In places 52° of N. latitude, this star passes the meridian within two or three minutes of the zenith. It is a star of about the fifth magnitude. It is 28 degrees nearly due east from the bright star *Vega*, or *a* Lyræ, in the constellation of the Harp, and nearly nine degrees south by east of *Deneb*, or *a Cygni*, the principal star in the Swan.

cluded *the intrinsic light of Sirius to be nearly that of* FOURTEEN SUNS." Sir William Herschel informs us that, with a magnifying power of 6450, and by means of his new micrometer, he found the apparent diameter of *Vega* or *a* Lyræ to be 0‴355: this will give the real diameter of this star about *thirty-eight* times that of the sun, or 33,440,000 miles, supposing its parallax to be one second. Were this its true estimate, its solid contents would be 19,579,357,857,382,400,000,000,* or above nineteen thousand five hundred and seventy-nine *trillions* of miles; which is *fifty-four thousand eight hundred and seventy-two times* larger than the solid contents of the sun. The magnitude of such a globe is altogether overpowering to the human imagination, and completely baffles every effort to approximate to a distinct conception of an object of such amazing amplitude and splendour. We have formerly shown† that the *sun* is a body of so vast dimensions that the human mind, in its present state, can form no adequate conceptions of it; that it is more than 500 times greater than all the planets, satellites, and comets of our system; that it is equal to thirteen hundred thousand globes as large as the earth; that its surface contains an amplitude fifty-three millions seven hundred and seventy thousand times larger than the view from Mount Etna, which comprises an extent of 45,000 miles; and that, were a landscape on the sun of this extent to be contemplated every two hours, it would require twenty-four thousand five hundred years before the wole surface of this luminary could be in this manner surveyed. What, then, shall we think of the probable existence of a luminous globe fifty-four thousand times greater than the expansive globe of the sun!

However amazing the magnitude of such a body may appear, we ought not on this account to consider the existence of such an orb as either improbable or incredible. Prior to the first discoveries of modern astronomy two or three centuries ago, no one could have believed that the sun is a body of such an immense size as he is now found to be, or that the planetary system occupies so extensive a range as astronomers

* In some editions of the "Improvement of Society" (p. 236), this number is inaccurately stated, the cube of the diameter having been by mistake substituted for the solid contents of the body; but the general result of the comparative magnitudes of the two bodies is the same.

† "Celestial Scenery," chap. iii., sect. 10, p. 222 and 223.

have now determined it. And we are not to conceive that even the immense amplitude of the sun is the highest scale of magnitude which the Creator has prescribed to himself in his arrangements of the universe. From the knowledge we have already acquired of the vastness of the scale on which creation is constructed, we have reason to believe that bodies exist in it far surpassing, in magnitude and grandeur, any of the globes to which we have alluded. There are certain lucid specks in the heavens which can only be perceived by the most powerful telescopes, which we are quite certain, from their immense distance, must comprise a mass of matter thousands of times larger than our sun; either a distinct mass of materials, or a congeries of shining globes so near each other that the separate bodies cannot be distinguished. As the distances between the greatest globes of the universe are incomprehensible by limited intellects, so the *magnitude* of some of these bodies may be so great as to surpass every estimate and every conception we may have hitherto formed on this subject. Such views of the magnitudes of creation are quite in accordance with the ideas we ought to entertain of a Being who is eternal, omnipresent, omnipotent, and incomprehensible.

But, without going beyond the strict deductions of science, we may fairly conclude that there are few stars in the concave of our sky that do not equal, and even surpass, our sun in size and in splendour; and if so, what a glorious and overwhelming scene does creation present to an intelligent and contemplative mind! Here we are presented with a scene on which the highest order of created beings may expatiate for myriads of ages, and objects, ever wonderful and ever new, may still present themselves to the astonished mind throughout the whole length of its immortality; so that the most expansive intellects shall never want subjects of sublime investigation during all the revolutions of an interminable existence.

We are not to imagine that all the stars, even those which appear with the same brilliancy, are of the same size. We have reason to believe that a *variety*, in this respect, exists among the distant orbs, as well as among the bodies which compose the planetary system, and in other departments of nature. Various considerations tend to show, that "one star differeth from another star in glory," not only as they appear

to the naked eye, but in *reality*, as to their intrinsic magnitude and splendour. Some of the telescopic stars appear of very different colours, one exhibiting rays of an orange or ruddy hue, another blue, another yellow, and another green, indicating a difference in their constitution, and in the nature of the light they emit. Among the double stars, the one which is found revolving around the other is evidently the smaller body, as its light is not distinguishable without a high magnifying power, and yet its distance from the earth must be nearly the same as that of the larger star around which it revolves. Recent observations tend to prove that some of the smaller stars have not only a greater annual parallax than those which are most brilliant, but an absolute motion in space much greater than those of the brightest class, which indicates that there is a difference in the real size of those bodies, and that some of the stars which appear smallest to our eye may be the largest in real dimensions; but the smallest of them are, undoubtedly, bodies of such magnitudes as surpass our distinct comprehension.

Some readers, from their ignorance of the mathematical principles of astronomy, and from being incapable of appreciating the observations to which we have referred, are apt to view with a certain degree of skepticism the conclusions which astronomers have deduced respecting the distances and magnitudes of the stars. Perhaps the following consideration, level to the capacity of every man of common sense, may have a tendency to convince even the most skeptical that the stars are situated at an almost incalculable distance from the earth.

Suppose a telescope to magnify 400 times, that is, makes a distant object appear four hundred times nearer, and four hundred times larger in diameter, than to the naked eye. With an instrument of this description I have been enabled to read a person's name, the letters of which were not above half an inch in length or breadth, at the distance of more than two miles. When this telescope is directed to the moon, it enables us to perceive the shadows of its mountains, and other minute portions of its scenery, and even to distinguish rocks and cavities less than a mile in diameter. When directed to the planet Venus, it exhibits it as a large splendid body, with either a gibbous, a half moon, or a crescent phase. When directed to Jupiter and Saturn, it makes these orbs appear sev-

eral times larger than the moon does to the naked eye, and enables us to see the dark belts which run across the one, and the rings which surround the other. Now if this same instrument be directed to the fixed stars, it shows them only as so many luminous *points*, without any well-defined diameters. It brings to view hundreds and thousands of stars which the naked eye cannot discern; but, although they appear somewhat more brilliant, they appear, on the whole, no larger in diameter than the stars in general do to the unassisted sight. This circumstance I consider as a palpable and *sensible* evidence of the immense distance of the fixed stars; for bodies at the distance of nine hundred, and even of eighteen hundred millions of miles, appear magnified in proportion to the power of the instrument; and why should not the fixed stars appear magnified in the same proportion, and present to the eye large disks like the planets, were it not on account of their incalculable distance? Were they only at a moderate distance from the planetary system—suppose ten times the distance of Saturn, or nine thousand millions of miles—this would undoubtedly be the case; but observation proves the contrary. When we view a planet—for example, *Saturn*, which is distant nine hundred millions of miles—through a telescope magnifying 400 times, we contemplate it as if we had been carried to a point only the four hundredth part of its distance; that is, we view it as if we were brought within little more than *two millions* of miles of its surface. In other words, we see it of the same magnitude, and nearly with the same distinctness, as if we had surmounted the law of gravitation, and been transported more than 897 millions of miles from our present abode in the direction of that orb.

When such an instrument is directed to the fixed stars, it does not lose its power as a telescope; this is proved by its presenting the *nebulæ*, which are invisible to the naked eye, as large, well-defined spaces in the firmament. It carries us within the four hundreth part of their actual distance, and enables us to contemplate them just as we would do if we were 400 times nearer them than we are. Let us suppose, as formerly, the distance of the nearest stars to be 20,000,000,000,000, or twenty billions of miles, we contemplate such stars by this instrument as if we were carried to a station nineteen billions nine hundred and fifty millions of miles from the place we now occupy, where we should still be fifty thousand millions

of miles* distant from these bodies. Supposing the sun were removed to a point fifty thousand millions of miles from the place he now occupies, which is 526 times his present distance, he would appear 526 times less in diameter than at present, or under an angle of little more than 3½ seconds, which is less than the apparent diameter of Uranus, a body which is generally invisible to the naked eye; so that if a star be distant twenty billions of miles, and equal to the sun in magnitude, it should appear no more than a point when viewed with a telescope magnifying 400 times. Supposing, then, that we were transported through the immense space of 19,950,000,000,000 miles, we behooved to be carried forward several thousands of millions of miles farther before those distant orbs would appear to expand into large disks like the moon, or like Jupiter and Saturn, when viewed through telescopes.

The above considerations prove to a demonstration that the nearest stars are removed from us at immense and inconceivable distances; and if their distance be so great, their *magnitudes* must likewise be astonishing, otherwise they would be altogether invisible either to the naked eye or by the telescope; for a distant visible object must always be considered as having a magnitude proportional to its distance and its *apparent* diameter.

* The following is the calculation expressed in figures:

400) 20,000,000,000,000, dist. of the star.
50,000,000,000, dist. as viewed by the telescope.

19,950,000,000,000, dist. from the earth at which we view it

CHAPTER VI.

ON NEW STARS.

To almost every eye but that of the astronomer, the starry firmament presents the same general aspect. To a common observer, the nocturnal heavens exhibit the appearance of a vast concave bespangled with countless numbers of shining points, of various degrees of brilliancy, and distributed over the sky apparently without any order or arrangement. Whether the clusters of stars which are seen in summer and in winter are the same; whether the stars which are seen in one region of the heavens at six o'clock in the morning are identically the same which are seen in the same quarter at midnight or at three in the morning; whether there be any stars which were seen by our forefathers which are no longer visible; whether any stars unknown to former generations can now be traced in the firmament, or whether any of those orbs which are visible at one time are invisible at another, to such inquiries there is not one out of a thousand of those who have occasionally gazed at the starry heavens that could give a satisfactory reply. It is the industrious astronomer alone, who, with unwearied observation, spends sleepless nights in surveying the various regions of the celestial vault, that can tell with certainty whether or not any changes occasionally take place in reference to any of the starry orbs.

The first account we have of any changes having been perceived among the stars is that recorded by Hipparchus of Rhodes, a celebrated astronomer who flourished about 120 years before the Christian era. About this period, this accurate observer of the heavens perceived, in a certain part of the firmament, a star which he had never observed before, and of which he could find no record in the observations of his predecessors. Struck with this new and unexpected phenomenon, he began to doubt whether changes might not happen among the celestial orbs as well as in the scene of nature here below. In order that such changes, when they happen, might be known to future generations, he began to form a cat-

alogue of all the stars visible in that part of the world where he resided, noting down the place and apparent magnitude of each star, till he at length completed a list of all the visible stars in the heavens; which was the first catalogue of those luminaries of which we have any account in history. It is much to be regretted that we have no specific account of the particular part of the heavens where this new star appeared, as it might have led us to determine whether it be still visible, or whether it be subject to periodical changes, or have altogether disappeared.

In the year 130 after the Christian era, another new star is said to have made its appearance. In the year 389 a new star appeared near *α* Aquilæ, or Altair, in the constellation of the Eagle. Its appearance was sudden; it continued three weeks, emitting a splendour equal to that of Venus, and afterward entirely disappeared. In the ninth century a new star appeared in the fifteenth degree of Scorpio, which is said to have emitted as much light as is reflected from one quarter of the moon. In 945 a new star appeared between the constellations of Cepheus and Cassiopeia; and another, in 1264, near the constellation Cassiopeia; but of these stars the accounts are so vague and imperfect that we can form no distinct conceptions of the phenomena they exhibited.

The most striking and wonderful phenomenon of this kind, of which we have an authentic and distinct description, occurred in the beginning of November, 1572, when a new star appeared in Cassiopeia, forming nearly a rhombus with the three largest stars, α, β, γ, of that constellation. Its appearance was sudden and brilliant. Its phenomena were so striking, that the sight of it determined the celebrated Tycho Brahe to become an astronomer. He did not see it at half an hour past five, when he was returning from his house to his laboratory; but returning about ten, he came to a crowd of country people who were staring at something behind him. Looking round, he saw this wonderful object. It was so bright that his staff had a shadow; it was of a dazzling white, with a little of a bluish tinge. It had no tail or hair around it similar to comets, but shone with the same kind of lustre as the other fixed stars. Its brilliancy was so great as to surpass that of *Lyra* and *Sirius*. It appeared even larger than Jupiter, which was then at its nearest approach to the earth, and by some was estimated to be superior to the

planet Venus in its greatest lustre. It was even seen by those who had good eyes at noonday; a circumstance which never happens in the case of any of the other stars, or even of the planets, except Venus, which has sometimes been seen in daylight in certain peculiar positions. During night, it was frequently seen through thin clouds which entirely intercepted the light of the other stars. In this state it continued to shine with undiminished brilliancy during the remaining part of November, or more than three weeks. It did not, however, continue much longer with this degree of brightness, but gradually diminished in its lustre. In the month of December it appeared to be only equal to Jupiter; in January, 1573, it appeared a little less than that planet, but still somewhat larger than stars of the first magnitude, to which it appeared about equal during the months of February and March; thus gradually diminishing in brightness, in April and May it was like a star of the second magnitude; in the months of June, July, and August, it was equal only to the largest stars in Cassiopeia, which are mostly of the third magnitude; in September, October, and November, it was no larger than a star of the fourth magnitude; in December, it was about equal to the star called *Gamma*, which was nearest to it; towards the end of 1573, and during the month of January, 1574, it was but little superior to stars of the fifth magnitude; in February it was no larger than a star of the sixth magnitude; and in the month of March it entirely disappeared, having continued visible from the beginning of November, 1572, to March, 1574, a period of about sixteen months. It was remarked that as it diminished in size it was likewise subject to certain changes in colour and brightness. When it appeared largest, its light was *white* and brilliant; after which it appeared a little *yellowish;* and in the beginning of spring, 1573, it approached something to the colour of Mars, being reddish like the star *Aldebaran*, or the Bull's Eye, and a little less bright than the star in the right shoulder of *Orion*. In the month of May that year it was of a pale livid white, like Saturn; which colour, as likewise its sparkling appearance, continued to the last, only growing more dim and faint as it approached the period of its disappearance.

Such were the appearances and changes of this wonderful star. These phenomena were particularly observed by several astronomers of that period, especially by Tycho Brahe, who

wrote a treatise on the subject, in which he determined its longitude and latitude, and demonstrated that it was situated in the region of the fixed stars, at a much greater distance from the earth than the sun, moon, or any of the planets, as it had no sensible parallax, and remained in the same point of the heavens during the whole period of its appearance. This star was likewise diligently observed by Cornelius Gemma, who says, that on the night of the 8th of November, 1572, he viewed with some attention that part of the heavens, in a very serene sky, but saw nothing uncommon; but that the next night, Nov. 9th, it appeared with a splendour surpassing all

Fig. 9

the fixed stars, and scarcely less bright than Venus. The longitude of this star, as determined by Tycho, was 9° 17; and 53° 45′ of north latitude.

The point in the heavens where this star appeared may be ascertained from the preceding figure, which exhibits a representation of the principal stars in Cassiopeia. The general position of this constellation may be found from the map of the circumpolar stars, Plate III. It is almost directly opposite *Ursa Major*, or the Great Bear. A line drawn from the Bear through the Pole-star meets Cassiopeia at nearly an equal distance on the other side of that star. When the Bear is at its lowest position below the pole, Cassiopeia is near the zenith, and *vice versa*. In the preceding representation (fig. 9), the large star towards the left points out the place which was occupied by the new star, which, with the three stars α, β, γ, forms a kind of rhombus or irregular square. The one on the left above the new star is β, and is also known by the name of *Caph*. The one to the right of Caph and a little higher is α, distinguished likewise by the name *Schedir*. Below Schedir, and a little to the right, is the star γ, or *Gamma*. About six degrees northwest of Caph, the telescope reveals to us a pretty large nebula of small stars, apparently compressed into one mass, with a number of loose stars surrounding it.

In the year 1604, about the end of September, another new star appeared near the heel of the right foot of *Serpentarius*. At that time, near the same part of the heavens, the planets Mars, Jupiter, and Saturn were very near each other, a phenomenon which so engaged the attention of astronomers that no uncommon appearance in that quarter of the heavens could long have escaped detection. On the 17th of September, Kepler, who wrote a treatise on this star, carefully observed the three planets; on the 23d he again viewed Mars and Jupiter, then approaching to their conjunction; and one of his scholars made the same observation on the 27th. On the 28th and on the 29th, which was the day when Mars and Jupiter were in conjunction, they were observed by *Mæstlinus* and others; but none of them as yet saw anything of the new star. On the 30th the sudden breaking of the clouds afforded one of Kepler's friends an opportunity of having a very short view of it; for in looking for Mars and Jupiter, he saw a bright star near them which he had not seen before, but it was soon obscured by clouds. On the 2d, 3d, 4th, and 6th of October, it was seen by several persons in different places. On account of cloudy weather at Prague, where

Kepler resided, he did not see it till the 8th of that month. All the observers agreed in this, that it was exactly round, without any beard or tail; that it was exactly like one of the fixed stars; and that, in the vividness of its lustre and the quickness of its sparkling, it exceeded anything they had ever seen before. As to its *colour*, it was remarked that it was every moment changing into the colours of the rainbow, as yellow, orange, purple, and red, but was generally white when at a little height above the vapours near the horizon. At its first appearance it seemed larger than any of the fixed stars, and even surpassed Jupiter, which planet was near it during the whole of October, and by its steady light was easily distinguishable from this vehemently sparkling star. It continued of the same size and brilliancy during the whole of October. About the end of this month the sun was approaching that part of the heavens in which the star appeared, yet on the 30th it was so much brighter than Jupiter that Kepler could see it distinctly when Jupiter was imperceptible, on account of the light of the sun, though he was farther from the sun's beams than the star. On the 6th and 8th of November it was seen by Kepler and others, and at Turin on the 13th, which appears to have been the last time it was perceived before being overpowered by the solar rays. After emerging from the sun's rays, on the west, it was seen in the morning on the 24th December, and though it sparkled exceedingly, yet it was considerably diminished in magnitude, appearing, however, larger than the bright star *Antares*. From the middle of January, 1605, till the middle of March, it gradually diminished in brightness. In the beginning of April it appeared like a star of the third magnitude, and continued nearly of the same size during the months of May, June, and July, and continued to sparkle more strongly than any other fixed star. On September 28th, a year after its first appearance, it was more brilliant than the star in the leg of Serpentarius, which is reckoned of the third magnitude. As it was at this time again approaching to the vicinity of the sun, it does not appear to have been seen after this period. In December, 1605, and January, 1606, cloudy weather prevented observations after it had emerged from the solar rays. Kepler concludes that it must have disappeared some time between October, 1605, and the following February, but on what day is uncertain. Like the former star which appeared in Cassiopeia,

it had no parallax, and remained in the same point of the heavens.

None of the new stars whose phenomena we have described above have ever reappeared, the places which they occupied still remaining a blank. It is much to be regretted that the telescope was not invented at the periods when these stars appeared, as it might have been ascertained by that instrument whether they had any sensible diameters. At any rate, their gradual decrease of magnitude and lustre might have been traced by a good telescope for a long period, perhaps for years, after they disappeared to the naked eye, which might have led us to draw some conclusions respecting the cause which produced so extraordinary phenomena. Were such a remarkable phenomenon to happen in our times, when telescopes, micrometers, and other astronomical instruments have received so many exquisite improvements, so as to enable us to penetrate deep into the profundity of space, and to measure the smallest angles, a variety of additional facts and circumstances would doubtless be discovered in relation to phenomena and events so striking and sublime.*

The subject of new stars, such as those now described, which blazed forth with so extraordinary a brilliancy and so soon disappeared, naturally gives rise to solemn and interesting reflections. There is a mystery that hangs over such sublime phenomena which produces in the mind an anxious desire to behold the veil removed, and to investigate the reasons and causes of such stupendous events. "It is impossible," says Mrs. Sommerville, when alluding to the star of 1572, "to imagine anything more tremendous than a conflagration that could be visible at such a distance." Whether there was anything in the existing state of the body alluded to similar to what we call a *conflagration* may be justly doubted; but there was a splendour and luminosity concentrated in that point of the heavens where the star appeared which would more than equal the blaze of *twelve hundred thousand worlds*

* Besides the above, the following instances of new stars may be noted: In the year 1670, a new star was discovered by Hevelius and Anthelm near the head of the Swan, which, after becoming invisible, reappeared, and after undergoing several singular fluctuations of light during two years, gradually vanished from the sight, and has never since been seen. Another new star is said to have been seen the same year at Paris, about the back of the Swan, which, after the space of fourteen days, vanished away.—Whiston's *Astronomical Lectures*, p. 45.

such as ours, were they all collected into one mass, and all at once wrapped in flames. Nay, it is not improbable that, were a globe as large as would fill the whole circumference of the earth's annual orbit to be lighted up with a splendour similar to that of the sun, it would scarcely surpass in brilliancy and splendour the star to which we refer; for during the whole period of its continuing visible it never appeared in the least to shift its position, though it was carefully watched by the astronomers of that age; and, consequently, the whole diameter of the earth's orbit, while the earth passed from one extremity of it to another, appeared only as a point at the vast distance at which the star was situated. These may appear bold positions, but they are in some measure warranted by the facts of the case, and they are perfectly consistent with what we know of many of the other astonishing operations of that Almighty Being who is "wonderful in counsel and excellent in working," and "whose ways" in providence and creation "are past finding out."

It is natural to inquire what may have been the cause of phenomena so extraordinary and sublime; but our limited views of creation, and of the plans and purposes of its Omnipotent Contriver and Governor, prevent us from arriving at any satisfactory conclusions. La Placé says, in reference to this subject, "As to those stars which suddenly shine forth with a very vivid light, and then vanish, it may be supposed, with probability, that great conflagrations, occasioned by extraordinary causes, take place on their surfaces; and this supposition is confirmed by their change of colour, analogous to that which is presented to us on earth by bodies which are consumed by fire."* But such an opinion, however great the astronomer who proposed it, appears quite unsatisfactory. We err egregiously when we attempt to compare the puny operations and conflagrations which happen on our globe with a scene so far transcending everything we behold in this terrestrial sphere. The greatest conflagration that was ever witnessed on earth cannot bear the smallest proportion or similitude to an object which must have occupied a space more than ten hundred thousand times the solid contents of our globe; nor is it likely that the agents or elementary principles which produced the respective phenomena were at all similar.

* *System of the World*, vol. i., p. 101.

The late Professor Vince, one of the most learned astronomers of his age, has the following remark: "The disappearance of some stars may be the destruction of that system at the time appointed by the Deity for the probation of its inhabitants, and the appearance of new stars may be the formation of new systems for new races of beings then called into existence to adore the works of their Creator."* The late Dr. Mason Good seemed to indulge in a similar opinion. "Worlds, and systems of worlds," says he, "are not only perpetually creating, but also perpetually disappearing. It is an extraordinary fact, that, within the period of the last century, not less than thirteen stars, in different constellations, seem to have totally perished, and ten new ones to have been created. In many instances it is unquestionable that the stars themselves, the supposed habitation of other kinds or orders of intelligent beings, together with the different planets by which it is probable they were surrounded, have utterly vanished, and the spots which they occupied in the heavens have become blanks. What has befallen other systems will assuredly befall our own. Of the time and the manner we know nothing; but the fact is incontrovertible; it is foretold by revelation; it is inscribed in the heavens; it is felt throughout the earth. Such is the awful and daily text; what, then, ought to be the comment?" Similar to these were the sentiments of the late Professor Robinson, of Edinburgh: "What has become of that dazzling star, surpassing Venus in brightness, which shone out all at once in November, 1572?" "Such appearances in the heavens make it evident that, notwithstanding the wise provision made for maintaining that order and utility which we behold in our system, the day may come 'when the heavens shall pass away like a scroll that is folded up, when the stars in heaven shall fall, and the sun shall cease to give his light.' The sustaining hand of God is still necessary, and the present order and harmony which he has enabled us to understand and admire is wholly dependant on his will, and its duration is one of the unsearchable measures of his providence."

Such are the pious sentiments of the above-named respectable philosophers in reference to the subject under consideration; but it may be questioned whether they are altogether

* Vince's "Complete System of Astronomy."

judicious, or correspondent to the perfections of the Creator and the arrangements he has made in the universe. They seem to take for granted that those stars which have blazed for a while, and then disappeared, have been destroyed or annihilated. We are indeed informed that, in regard to our globe, a period is approaching when "the elements shall melt with fervent heat, and the earth and the works that are therein shall be burned up." But such a conflagration cannot be justly compared to the splendours of those wonderful stars described above. At whatever period in the lapse of duration such an event may take place, it will be so far from being visible at the nearest star, that it would not be seen by such eyes as ours at the boundaries of our system. Besides, we are assured, in that revelation which announces it, that that awful event shall take place as one of the consequences of the sin and depravity of man; and, therefore, we have no reason to believe that it will extend to the sun, or any of the surrounding planets of our system; nor have we any reason to conclude that the conflagration of our globe will issue in its entire destruction, or that the elementary principles of which it is composed will be annihilated. It is more probable, nay, almost certain, that this tremendous event will only tend to purify our globe from the physical evils which now exist, and to transform it into a new and happier world for the residence of renovated and pure intelligences. In regard to *annihilation*, we have no proof that any particle of matter which was ever created has yet been annihilated.* Incessant changes and transformations are going forward both in the scene of sublunary nature and throughout the celestial regions; but changes in material objects do not necessarily imply the *destruction* of the matter of which they are composed, but simply a new arrangement or mode of operation. We have no reason to believe that any portions of matter which now exist throughout the universe will ever be reduced to annihilation. On the other hand, we have palpable evidence, from several phenomena in the heavens, that the work of creation is still going forward, and that the Creator is gradually ushering into existence new suns, and systems, and worlds; and, in all probability, his creating energy will be con-

* See "Philosophy of a Future State," chap. i., sec. 10; and "Christian Philosopher," 7th edit., p. 354.

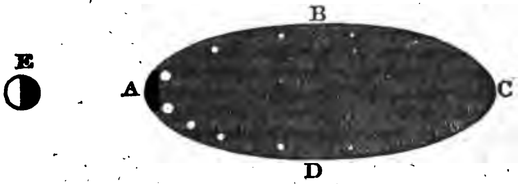
tinually exerting itself throughout all the succeeding ages of eternity.

Again, if that grand and terrific event which is to put a final period to the present terrestrial system is to be viewed as a consequence of the introduction of moral evil and the depravity of man, then we are led to conclude that those intelligences which were connected with the systems which are supposed to have been destroyed, must have been involved in the guilt of moral degeneracy, or, in other words, in rebellion against their Creator; otherwise, why were they subjected to such an awful catastrophe, and doomed to be blotted out of existence? We have no ground for entertaining any such supposition. Reasoning from the *benevolence* of the Deity, it is more probable to conclude that the inhabitants of our world are almost the only intelligences throughout the universe who have swerved from the path of original rectitude, and violated the moral laws of their Maker. Nor is it likely that the *whole inhabitants* of any system—consisting, perhaps, of thirty or even a hundred worlds—would be found uniting in rebellion against the moral government of their Benefactor, so as to warrant the *entire* destruction of the system with which they were connected. Besides, were the views of the philosophers to which I allude to be adopted, then we must admit that the systems which, in their opinion, were destroyed or annihilated, must have continued in existence only for a year or two; for no luminous bodies occupied the places of the new stars before they burst on a sudden to the view, and no twinkling orbs have been seen in these points of the heavens since they disappeared; but it is surely not at all probable that the Almighty would launch into existence systems of such amazing magnitude and splendour, and suffer them to rush into destruction within a period of so very limited duration.

For the reasons now stated, and others which might have been brought forward, I cannot acquiesce in the views of the respectable philosophers to which I have adverted; but it is easier to set aside an untenable hypothesis than to attempt an explanation of the real causes of so sublime and wonderful phenomena. In investigating the distant wonders of the universe and the arrangements of the Divine government, it becomes us to express our sentiments with modesty and caution. Whatever may have been the causes which produced the sudden splendour and the rapid disappearance of the new

stars, I entertain not the least doubt that those bodies are still in existence, and subserving important purposes in the economy of God's universal government. Almost any hypothesis is to be preferred to that which supposes their destruction or annihilation. What should hinder us from concluding that the extraordinary phenomena of the star of 1572 was owing to a luminous orb of immense magnitude, accompanied with a retinue of worlds, *moving with inconceivable velocity in an immense elliptical orbit, the longer side of which was nearly in a direction to our eye;* that its most brilliant appearance was when it was nearest our system, as at A (fig. 10), supposing E the relative position of the earth or of our system;

Fig. 10.



and that, as it gradually declined in its brightness, it was passing along the curve from A towards B and C, till its rapid flight at length carried it beyond the limits of human vision? Had telescopes been in use at that period, there is little doubt it would have been seen, though still diminishing, for a much longer period than that in which it was visible to the unassisted eye; in which case it would have fully corroborated the opinion now stated. In confirmation of this explanation of the phenomena, it has been supposed, with a high degree of probability, that it is the same star which appeared in the year 945 and in 1264, which, of course, would have a period of revolution of about 319 years, which period might vary two or three years in the course of its revolutions, from causes with which we are unacquainted, as we find sometimes happens in the case of comets. This opinion is rendered the more probable from the consideration that the stars of 945 and 1264 appeared in the constellation of *Cassiopeia*, where likewise the star of 1572 was observed; and if these be identical, then it is probable that it will again make its appear-

ance about the year 1891 or 1892; and if so, astronomers will then have a better opportunity of marking its aspects and motions, and determining its size and its period of revolution.

If this explanation appear the most probable, it presents to the mind a most magnificent and overwhelming idea, without supposing anything so tremendous and terrific as a sudden conflagration. It presents before us a luminous globe of astonishing magnitude—perhaps not less than a hundred times the size of our sun—winging its course over a circuit perhaps a thousand times more expansive than the orbit of Uranus, and carrying along with it a hundred worlds in its swift career. The motion of such a body must have been rapid in the extreme, when we consider the rapid diminution of its apparent magnitude. In the month of November it first appeared; in December its brightness was sensibly diminished; in the month of April following it had diminished to the size of a star of the second magnitude; in July, to one of the third magnitude; in October, to one of the fourth; in the following January, to one of the fifth; in February, to one of the sixth magnitude; and in March it disappeared.

Now, according to Sir W. Herschel's experiments, the light of a star of the *first* magnitude being supposed 100, the light of one of the second magnitude is 25, one of the *third* magnitude 12, &c. (see p. 37). If, then, we suppose these classes of stars to be nearly of equal magnitudes, and that their distance is in an inverse proportion to the diminution of their light, it will follow that a star of the second magnitude is four times the distance of a star of the first; a star of the third magnitude four times the distance of the second, or eight times the distance of the first magnitude, &c Supposing, then, the star of 1572 to have been twenty billions of miles from the earth at its nearest approach to our system: from December, 1572, to April, 1573, when it was diminished to the apparent size of a star of the second magnitude, it must have moved four times that distance, or eighty billions of miles, during these four months, which is at the rate of six hundred thousand millions of miles a day, and four hundred and sixty-two millions a minute, a velocity of which we can have no adequate conception.

If the above explanation be unsatisfactory, I know not to what hypothesis to resort for a solution of this mysterious and

wonderful phenomenon. Whatever view we may be disposed to take of such striking events, we are lost in admiration and wonder. We behold a display of magnitude, of motion, and of magnificence, which overpowers the human faculties, which shows us the littleness of man and the limited nature of his powers, and which ought to inspire us with reverence of that Almighty Being who sits on the throne of the universe, directing all its movements for the accomplishment of his wise and righteous designs, and for the diffusion of universal happiness throughout all the ranks of intelligent existence. However astonishing the conclusions we are led to deduce from the phenomena under consideration, the facts to which we have adverted are not beyond the energies of Him whose perfections are strictly *infinite*. Nay, from such a Being, who is self-existent and omniscient, who fills the immensity of space with his presence, and whose power is boundless in its operation, we should naturally expect that displays of creating and sustaining energy would be exhibited altogether overwhelming and incomprehensible by mortals. "Canst thou by searching find out God? Canst thou find out the Almighty to perfection? In the heights of heaven he doth great things past finding out, yea, and wonders without number. By his Spirit he hath garnished the heavens. The pillars of heaven tremble and are astonished at his reproof. Lo, these are but parts of his ways; but the thunder of his power who can understand?"

CHAPTER VII.

ON VARIABLE STARS.

When the starry firmament is attentively surveyed, and the aspects of the numerous orbs it contains particularly marked, it is found that several of these bodies are subject to periodical changes in the brilliancy of their light and in their apparent diameters, indicating in some instances motions and revolutions of considerable extent. The following sketches contain descriptions of the more remarkable phenomena connected with this class of the heavenly bodies, generally known by the name of *variable* or *periodical* stars:

The first star of this kind which seems to have been particularly noticed is one in the neck of the Whale, whose right ascension is 2h 8′ 33″, and south declination 3° 57′ 25″. It was first observed on August 13th, 1596, by David Fabricius, when it appeared like a star of the third magnitude, but disappeared after the month of October in the same year. It was again observed by Holwarda in the year 1637; and after having disappeared during a period of nine months, it again became visible; since which time it has been found every year pretty regular in its period, except from October, 1672, to December, 1676, during which time Hevelius could not perceive it, though it was a particular object of his attention. Bullialdus, a Frenchman, having compared together the observations that had been made on it from 1638 to 1666, determined the periodical time between its appearing in its greatest brightness and returning to it again to be 333 days. He found also that about 120 days elapse between the time that it is first seen of the sixth magnitude and its disappearing; that it continues in its greatest lustre for about fifteen days; that after its first reappearance of the sixth magnitude it increases in size much faster till it comes to be of the fourth magnitude, than it does from that period to its being of the third; and that from its being of the third it increases to the second magnitude by still slower degrees. Modern astronomers give the following description: "It remains in its greatest brightness about a fortnight, being then nearly equal to a star of the second magnitude; it decreases during three months, till it becomes completely invisible, in which state it remains about five months, when it again becomes visible, and continues increasing during the remaining three months of its period; but it does not always return to the same degree of brightness, nor increase and diminish by the same gradations." It appears about twelve times in eleven years. Cassini determined its period to be 334 days; but Sir W. Herschel makes it 331 days, 10 hours, 19 minutes. It appears, then, that this star passes through all the gradations of light and magnitude from a star of the second to a star of the sixth magnitude and under; but after it has disappeared to the naked eye it may be traced to its lowest magnitude by a telescope of moderate power. It is sometimes distinguished by the name of *Stella Mira*, or the wonderful star, and *Omicron Ceti*.

In 1704, Maraldi observed a variable star in the constellation *Hydra*. This star had been described by Montanari in 1670, but was not visible in April, 1702. Maraldi saw it for the first time in the beginning of March, 1704, in the same place where it had been seen thirty-four years before. It appeared of the fourth magnitude, and continued nearly in the same state till the beginning of April. It then gradually diminished till the end of May, when it could no longer be seen by the naked eye, but was visible through the telescope for a month longer. It could not be seen again till the end of November, 1705, when that part of the heavens began to emerge from the sun's rays. It was then very faint, and grew less and less till the end of February, 1706, and could then be scarcely perceived even with a telescope. It did not reappear till the 18th April, 1708, when it was larger than a star of the sixth magnitude, and increasing in lustre. It was seen by the same observer afterward, in the years 1709 and 1712. From the observations of Maraldi, Mr. Pigot concludes that its period was then 494 days; but from observations made by himself, he thinks that *now* it is only 487 days; so that from the time of Maraldi it has shortened seven days. The following are the more prominent particulars relating to this star: 1. When at its full brightness it is of the fourth magnitude, and does not perceptibly change for the space of fourteen days. 2. It is about six months in increasing from the tenth magnitude and returning to the same; so that it may be considered as invisible during that time. 3. It is considerably more quick, perhaps one half more so, in its increase than in its decrease. 4. Though, when at its full, it may always be styled a star of the fourth magnitude, it does not constantly attain the same degree of brightness, but the differences are very small. 5. Its right ascension for 1786 was $13^h\ 18'\ 4''$; and its south declination $22^\circ\ 9'\ 38''$. It is marked No. 30 in Hevelius's Catalogue of the Stars; from which data, its place may easily be found on a planisphere or on the celestial globe.

In the year 1600, G. Jansonins discovered a variable star in the breast of the Swan, which was afterward observed by different astronomers, and supposed to have a period of about ten years. The results of Mr. Pigot's calculations from the observations of former astronomers are, 1. That it continues in full lustre for five years. 2. It decreases rapidly for two

years. 3. It is invisible to the naked eye for four years. 4. It increases slowly during seven years. 5. All these changes are completed in eighteen years. 6. It was at its minimum at the end of the year 1663. 7. It does not always increase to the same degree of brightness, being sometimes of the third, and at others only of the sixth magnitude. "I am entirely ignorant," says Mr. Pigot, "whether it is subject to the same changes in this century, having not met with any series of observations upon it; but if the above conjectures are right, it will be at its minimum in a very few years. Since November, 1781, to the year 1786, I have constantly seen it of the sixth magnitude, though I suspect that in 1785-6 it had rather decreased." This star is near *Gamma* in the Swan's breast: it varies from the third to the sixth, seventh, &c., magnitudes. Its right ascension is 20^h 9′ 54″; north declination 37° 22′ 37″.

One of the most remarkable of these changeable stars is that called *Algol*, in the head of Medusa, in the constellation *Perseus*. It had long since been known to appear of different magnitudes at different times; but its period was first ascertained by John Goodricke, Esq., of York, who began to observe it in the beginning of the year 1783. It changes continually from the first or second to the fourth magnitude; and the time which elapses from one greatest diminution to the other was found in 1783 to be, at a mean, 2 days, 20 hours, 49 minutes. The change is thus: during four hours it gradually diminishes in lustre; during the succeeding four hours it recovers its first magnitude by a like gradual increase; and during the remaining part of the period, namely, 2 days, 12 hours, 42 minutes, it invariably preserves its greatest lustre; after the expiration of which its diminution again commences. According to Mr. Pigot, who has made many observations on such stars, and paid particular attention to the subject, the degree of brightness of this star when at its *minimum* is variable at different periods; and he is of the same opinion in regard to its brightness when at its full; but whether these differences return regularly or not has not been determined. The right ascension of Algol, or β *Persei*, for 1786, was 2^h 54′ 19″; and its north declination 40° 6′ 58″. It is situated 12° east of *Almaach*, in the foot of Andromeda, and may be known by means of three stars of the fourth magnitude lying a few degrees southwest of it, and forming a small triangle. It

comes to the meridian on the 21st December, about nine o'clock in the evening; but as it continues above the horizon at least twenty hours out of the twenty-four, it may be seen every evening from August to May.

Another variable star is to be found in the neck of the Swan. The period of this star had been settled by Maraldi and Cassini at 405 days; but from a mean of the observations of Mr. Pigot, it appears to be only 392, or, at most, 396·7-8 days. The particulars relating to it are, 1. When at its full brightness, it undergoes no perceptible change for a fortnight. 2. It is about three and a half months in increasing from the eleventh magnitude to its full brightness, and the same in decreasing; for which reason it may be considered as invisible during six months. 3. It does not always attain the same degree of lustre, being sometimes of the fifth and sometimes of the seventh magnitude. The right ascension of this star is $19^h\ 42'\ 21''$; and its north declination $42°\ 22'\ 58''$. It is situated in the neck, nearly equidistant from *Beta* and *Gamma*, and south by west from *Deneb* Cygni, at the distance of about twelve degrees, and is marked *Chi*.

The star *Eta* Antinoi is another star of this description, whose variation and period were discovered by Mr. Pigot in 1785. From his corrected observations, he concludes that it continues at its greatest brightness forty hours without decreasing; it is sixty-six hours after it begins to decrease before it comes to its full diminution; after which it continues stationary for thirty hours more; and then increases for thirty-six hours. In every period it seems to acquire its full brightness, and to be equally decreased. Its period, therefore, is seven days, four hours; and its greatest and least variation is from the third to the fifth magnitude. Its right ascension is $19^h\ 41'\ 34''$; and its north declination $0°\ 28'\ 14''$. It is about eight degrees south from *Altair*, the principal star in the constellation Aquila.

The above descriptions may suffice as specimens of the phenomena of variable stars. There are about seven or eight other stars which have been observed to be certainly variable, among which are the following: A star in the Northern Crown, whose right ascension is $15^h\ 40'\ 11''$; north declination $28°\ 49'\ 30''$; and period $10\frac{1}{2}$ months. A star in Hercules, whose right ascension is $17^h\ 4'\ 54''$; north declination $14°\ 38'$; and period of variation $60\frac{1}{4}$ days. A star in So-

bieski's Shield, whose right ascension is 18^h 38′ 38″; south declination 5° 56′; and period 62 days. The star *Beta* Lyræ, right ascension 18^h 42′ 11′; north declination 33° 7′ 46″; greatest and last variation, 3, 4, 5; supposed period, 6 days, 9 hours. The star *Delta Cephei*, whose period is 5 days, 8½ hours; right ascension 22^h 21′; and north declination 57° 50′. With several others.

Besides these, whose variations and periods have been determined, there are about thirty-seven other stars, which are, with good reason, suspected to be variable, but whose periods of change have not yet been ascertained, on account of the want of a sufficient number of observers, who might devote their attention more particularly to this department of astronomical observation. For example, the star *Pollux*, or *Beta* Gemini, is suspected to change from the first to the third magnitude.

When contemplating such changes among bodies so immensely distant and of so vast magnitude, we are naturally led to inquire into the causes which produce those phenomena. Our ignorance, however, of the precise nature and constitution of those remote bodies, and of the scenes and circumstances in which they may be placed, prevent us from forming any definite or satisfactory conclusions. The following are some of the opinions which have been thrown out on this subject. It has been supposed that portions of the surfaces of these stars are covered with large black spots, which, during the diurnal rotation of the star, present themselves under various angles, and thus produce a gradual variation in its brilliancy. Sir W. Herschel says, "Such a motion may be as evidently proved as the diurnal motion of the earth. Dark spots, or large portions of the surface less luminous than the rest, turned alternately in certain directions, either towards or from us, will account for all the phenomena of periodical changes in the lustre of the stars so satisfactorily, that we certainly need not look for any other cause." Sir Isaac Newton thought that the sudden blaze of some stars may have been occasioned by "the falling of a comet into them, by which means they would be enabled to cast a prodigious light for a little time, after which they would gradually return to their former state." But we know too little about the nature of comets to be able to determine what effect they would produce in such a case, nor are we certain that such bodies

are connected with other systems. If the fixed stars be nearly of the same nature as the sun, it is highly improbable that any such effect would be produced, even although a comet were to fall into its luminous atmosphere, as that atmosphere appears to have nothing in it that would take fire by the approach of any extraneous body, or that would "blaze" like combustible substances on the earth. The blaze, if such an effect were to take place, would scarcely be distinguishable from our globe, and much less from a distant system. Maupertius, in a "Dissertation on the Figures of the Celestial Bodies," is of opinion that some stars, by their prodigious quick rotation on their axes, may not only assume the figures of oblate spheroids, but that, by the great centrifugal force arising from such rotations, they may become of the figures of millstones, or be reduced to flat circular planes, so thin as to be quite invisible when their edges are turned towards us, as Saturn's ring is in such positions. And when any eccentric planets or comets go round any fixed star, in orbits much inclined to its equator, the attraction of the planets or comets in their perihelions must alter the inclination of the axis of that star; on which account it will appear more or less large and luminous, as its broad side is turned more or less towards us. This opinion, at best, I consider as having a very small degree of probability, and almost quite untenable. Mr. Dunn, in a paper in vol. 52 of the "Philosophical Transactions," supposes that the interposition of some gross atmosphere may solve the phenomena under consideration. "The appearance of new stars," says he, "and the disappearance of others, possibly may be occasioned by the interposition of such an ethereal medium within their respective orbs as either admits light to pass freely or wholly absorbs it at certain times, while light is constantly pursuing its journey through the vast regions of space."

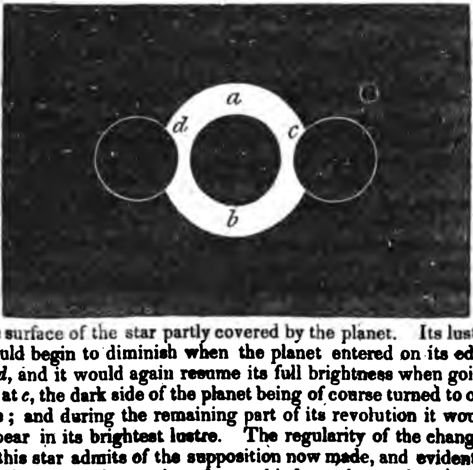
Whatever opinions we may adopt on this subject, it is evident that *the regular succession of the variations* of periodical stars preclude the idea of their being destroyed. It is likewise evident that *motion* of some kind or other, either in the stars themselves or in some bodies either directly or remotely connected with them, must be one of the causes of the phenomena in question; and it is not improbable that different causes in different instances may opperate in producing the effects. It does not appear to me probable that the cause

which produces the variation in the case of *Delta Cephei*, whose period is only 5 days, 8½ hours, is the same which produces all the variety of change which happens in the star *Gamma* in the Swan's breast, whose periodical changes are completed only in eighteen years. It is not unlikely that a rotation round an axis, which has the effect of presenting different sides of the star of more or less degrees of obscurity or brightness to the eye of a spectator, will account for the phenomena of such stars as *Eta* Antinoi and *Delta Cephei*; but it does not appear probable that a motion of rotation is so slow in any of these bodies as to occupy a period of eighteen years, as in the case of the star in the breast of the Swan.

I am disposed to consider it as highly probable, that *the interposition of the opaque bodies of large planets revolving around such stars* may, in some cases, account for the phenomena. It is true that the planets connected with the solar system are so small in comparison of the sun, that their interposition between that orb and a spectator at an immense distance would produce no sensible effect. But we have no reason to conclude that in all other systems the planets are formed in the same proportion to their central orbs as ours; but, from the variety we perceive in every part of nature both in heaven and earth, we have reason to conclude that every system of the universe is in some respects different from another. There is no improbability in admitting that the planets which revolve round some of the stars may be so large as to bear a considerable proportion (perhaps one half or one third) to the diameters of the orbs around which they revolve; in which case, if the plane of their orbits lie nearly in the line of our vision, they would, in certain parts of their revolutions, interpose between our eye and the stars, so as to hide for a time a portion of their surfaces from our view while in that part of their orbits which is next the earth. Such a supposition is by no means inconsistent with the operation of the law of universal gravitation; for although such planets bore a considerable proportion to the size of their central luminaries, yet we have only to suppose that their *density is very small*. They may be globes whose central parts are devoid of solid matter, consisting only of a solid external shell for the support of inhabitants, as is probably the case with the planet Saturn, whose density is only equal to that of cork.

A planet about the size we have now supposed revolving around a star would, in a great measure, account for the phenomena presented by *Algol*. This star accomplishes the period of its variations in 2 days and nearly 21 hours. During 3½ or 4 hours it gradually diminishes in lustre, and during the succeeding 4 hours it gradually recovers its first magnitude. Throughout the remaining part of the period, namely, 2 days, 12 hours, 42 minutes, it invariably preserves its greatest lustre; so that the time of its being diminished in lustre is only about the ninth part of its whole period of variation. Now supposing a planet about half the diameter of the star revolving around Algol, it would intercept a large portion of its surface when it passed between our eye and the star, as at *a b* (fig. 11), where the white circular ring represents

Fig. 11.

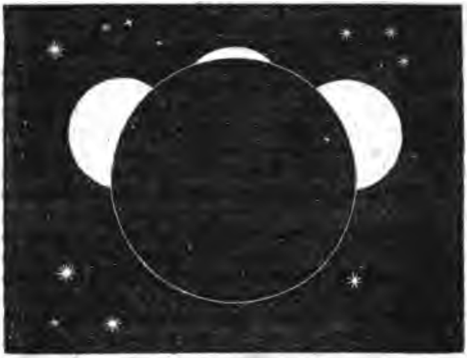


the surface of the star partly covered by the planet. Its lustre would begin to diminish when the planet entered on its edge at *d*, and it would again resume its full brightness when going off at *c*, the dark side of the planet being of course turned to our eye; and during the remaining part of its revolution it would appear in its brightest lustre. The regularity of the changes of this star admits of the supposition now made, and evidently requires a regular motion of some kind or other, either in the star itself or in some body connected with it, in order to produce the phenomena. Perhaps, in the case of some of the variable stars, we might suppose several large planets in suc-

cession to pass between our eye and the star to account for the appearance they present; a supposition which perfectly agrees with the idea of a *system* of revolving bodies.

As it is not probable that the changes of all such stars arise from the same cause, what should hinder us from supposing that *there are stars or suns that revolve around planets of a size immensely greater*; the planets, for example, bearing a similar proportion to the stars as the sun bears to Jupiter? Considering the immense variety of celestial mechanism throughout the universe, there can be no great improbability in such a supposition. The case of *double stars* demonstrates that one sun actually revolves round another; and why may not a sun revolve around a central planet, whose surface may contain forty times the area of all the planets of our system, in order to distribute light and heat, and other beneficial influences, to its numerous population? No violation of the law of universal gravitation is implied in such a supposition; and the Almighty is not confined to one mode of arranging systems and worlds. Supposing, then, such an arrangement to exist, it might account for the phenomena of some of the variable stars, particularly those which remain invisible for a certain period. Such are some of those formerly noticed, as the star in Hydra, and that in the breast of the Swan, and particularly a star in the Northern Crown, whose right ascen. is $15^{h}\,40'$, north declin. $28^{\circ}\,49'$, and period $10\frac{1}{2}$ months, and which decreases from the sixth to the ninth and tenth magnitude. It attained its full brightness about the 11th of August, 1795, and continued so for three weeks; in three and a half weeks it decreased to the tenth magnitude, and a few days afterward disappeared. After being a considerable time invisible, in April, 1796, it again appeared; on the 7th of May it reached the ninth magnitude, and then gradually attained its full brightness. If, then, such a star was revolving round a very large central planet, it is easy to conceive that in the more distant part of its course it might be hidden from our view, either in whole or in part, by the interposition of the opaque central body, as is obvious from an inspection of figure 12. And as the star now alluded to never exceeds in lustre a star of the sixth magnitude, it is not improbable that it is one of the inferior order of those luminous orbs which may revolve round an opaque body of superior magnitude.

Fig. 12.



Such, then, are some of the conceivable causes which may produce the phenomena of variable stars, although other causes may in some cases exist of which we have no conception. These phenomena evidently indicate that motions and revolutions of various kinds are going forward throughout the stellar regions; that the Almighty is superintending the movements of those provinces of his empire, and that all his agencies have a respect to the order and the happiness of intelligent existence.

Besides the periodical variations to which we have now adverted, there are several other striking changes which have been observed in the starry regions which deserve our attention, and which I shall briefly notice.

1. Several stars which were formerly distinctly visible, and are marked in different catalogues, are now wholly lost. The following are a few instances. M. Montanere, professor of mathematics at Bononia, in a letter to the Royal Society, of date April, 1670, gives the following statement: "There are now wanting in the heavens two stars of the second magnitude, in the stern and yard of the ship Argo. I and others observed them in the year 1664, upon occasion of the comet that appeared that year. When they disappeared first I know not; only I am sure that, in the year 1668, upon the 10th of April,

there was not the least glimpse of them to be seen, and yet the other stars about them, of the third and fourth magnitudes, remained the same. I have observed many more changes among the fixed stars, even to the number of a hundred, though none of them are so great as those I have showed." In 1670 Anthelm discovered a star of the third magnitude in the head of the Swan, which, after becoming completely invisible, reappeared, and after undergoing one or two singular fluctuations of light during two years, at last died away entirely, and has not since been seen. Sir William Herschel gives a list of thirteen stars, most of which are supposed to be lost. Of these are the following: Nos. 80 and 81 of Hercules, both of the fourth magnitude; the 19th of Perseus, of the sixth magnitude; and the 108 Pisces, are judged to be wholly lost. The stars 73, 74 Cancer, in the southern claw of the Crab, of the sixth magnitude, are either lost or have suffered such great changes that they can no longer be found. On this subject Sir John Herschel states, "The star 42 Virginis is inserted in the catalogue of the Astronomical Society from Zach's Zodiacal Catalogue. I missed it on the 9th of May, 1828, and have since repeatedly had its place in the field of view of my twenty-feet reflector without perceiving it, unless it be one of two equal stars of the ninth magnitude very nearly in the place it must have occupied."

2. Some stars have changed their magnitudes since the beginning of last century. A considerable number of stars, marked by Flamstead in his *Historia Celestis*, are now found to be of different magnitudes since the period in which he observed the heavens and formed his catalogue. For example: the 1st and 2d of *Hydra* are now only of the eighth and ninth magnitude instead of the fourth, as they are marked by Flamstead. The 31st and 34th of *Draco* have changed greatly; the 31st has increased from the seventh to the fourth, and the 34th has diminished from the fourth to the sixth or seventh magnitude. The 38th Perseus, instead of the sixth, has now increased to the fourth magnitude. About thirty stars of this description are reckoned by Sir W. Herschel to have changed their magnitudes.

3. There are stars unknown to the observers of former times which have recently become visible. The following, among others of this description, have been marked by Sir W. Herschel: 1. A star in the end of the Lizard's tail, of the

fourth or fifth magnitude, which is not recorded by Flamstead, although he notices one in that constellation less conspicuous. 2. A star near the head of Cepheus. 3. A considerable star in a direction from the 68th to the 61st of Gemini. 4. A star of considerable brightness preceding the first of the Little Horse. 5. A remarkable star between β and δ Hydræ. 6. A star near δ Hercules, of the fourth or fifth magnitude, with several others. Similar observations appear to have been made about the end of the seventeenth and the beginning of the eighteenth centuries, by Cassini and others. Cassini discovered a new star of the fourth, and two of the fifth magnitude in Cassiopeia; two in the constellation Eridanus, one of the fourth, the other of the fifth magnitude; and four of the fifth and sixth magnitudes near the north pole, which had not been perceived at a former period.

Such changes in bodies so far removed from our system, and of magnitudes so enormous as the least of them must be, naturally lead to the conclusion that revolutions of vast extent, and operations conducted on a most magnificent scale, are incessantly going forward in those remote and unexplorable regions. In the case of stars which have totally disappeared, we are led to conclude, either that some vast and important change has taken place in the *constitution* of certain worlds or systems, or that the central luminaries of such systems, with all their surrounding planets, have been transported by some unknown and almighty agency into more distant regions of space, where they may remain for ever hidden from our view. As to those stars which have changed their magnitudes within the last century, they may either be approaching to or receding from the system to which we belong, or their native brightness may be either increasing or diminishing from causes with which we are unacquainted; or some ethereal mediums of a peculiar nature may be interposed between our sight and those distant orbs. With respect to stars unknown to former observers which have recently become visible, it is not unreasonable to suppose that these are *new systems* recently launched from the creating hand of the Omnipotent, to diversify his creation and augment the glories of his empire, as well as to distribute happiness among new orders of sensitive and intelligent existence. We ought not to imagine that the work of creation, considered as a whole, is yet finished, or ever will be finished during an indefinite lapse of ages.

When it is stated by the inspired writer of the book of Genesis that "God rested from all his work," we are to understand the expression only in reference to the formation or *arrangement* of the world in which we reside into the form and order in which we now behold it; for to this arrangement chiefly, if not solely, the descriptions of the sacred historian in the first chapter of Genesis refer. It is in perfect accordance with the idea of a Being possessed of omnipotent power, boundless goodness, and endless duration, that his creating energies should never cease in their operation throughout all the periods of an interminable existence; and the phenomena to which we refer are a strong presumption, if not a demonstrable evidence, of a continued series of creations. These new creations may be bursting forth in the remote spaces of the universe, in various degrees of splendour and magnificence, to an extent of which we have no conception; and from the character and perfections of the Divinity, we have reason to believe that such processes will be incessantly going forward throughout all the ages of eternity.

Whatever opinions we may be disposed to form as to the phenomena to which we have adverted, they tend to convey to the reflecting mind magnificent views of the physical energies of the Almighty, in arranging the different departments of his boundless dominions, and accomplishing the purposes and plans of his moral government; and they naturally excite in the mind a desire of future existence, and an ardent wish to behold the veil which now intercepts our views of these glorious orbs withdrawn, and to contemplate the scene of divine operation in all its splendour and magnificence.

At first view, it may appear a circumstance of comparative insignificance to behold a small star, scarcely distinguishable to the eye, waxing brighter, or growing dimmer, or vanishing altogether from the view; or a star appearing in a point of the heavens which was unoccupied before. The distant blaze of a field of furze, the falling of a tower, or the conflagration of a cottage, may to some appear events of far greater interest and importance; but such events in the heavens as those to which we refer may be connected with scenes as astonishing, though perhaps not so tremendous, as if the sun were shorn of his rays and turned into darkness, and this earth and all the planetary globes shattered to their centres and wrapped in flames; or, as if a new sun of superior magnitude were to

appear in our system, and to illuminate our globe with a new species of light and colours. Objects at a great distance from the observer make little impression on the organs of vision, and seldom affect the mind. A fleet of the largest ships of war, viewed from the top of a tower at fifty miles' distance, appears only like a few almost undistinguishable specks on the verge of the horizon, while the fate of individuals, families, communities, and even empires, may depend upon the encounter in which they may be engaged. The conflagration of a city of ten hundred thousands of inhabitants may appear at a distance as only a faint glimpse of light in one point of the horizon, while palaces, and temples, and thousands of splendid fabrics are turned into smoking ruins, and multitudes are thrown into the utmost consternation, and perishing in the flames. The burning of the city of Moscow, as beheld from the moon when the dark side of the earth was presented to that orb, would appear only like a dim lucid speck, scarcely distinguishable from the other parts of the earth's surface. And if this be the case in respect to objects within such limited distances, what astonishing scenes may be the result of what we perceive in bodies many thousands of millions of miles distant, when we behold them disappearing to our view, or even when we perceive their light only increasing or diminishing? Here imagination is left to fill up the picture which the organs of vision so dimly perceive. We are to consider that the orbs to which we allude are luminous globes of immense size; that they are doubtless encircled with a retinue of worlds replenished with inhabitants; that what to us appears a slight change of aspect may to them be the commencement of an era of new glory and splendour; that the Almighty rules over those distant regions as well as "among the inhabitants of the earth;" and that all the changes which happen among them are in unison with his eternal designs, and subserve the ends of his universal government.

CHAPTER VIII.

ON DOUBLE STARS AND BINARY SYSTEMS.

In whatever part of creation we survey the operations of the Almighty, we uniformly find the characteristic of *variety* impressed upon all his works. This is evident in all the kingdoms of nature connected with our globe, where the multitude and diversity of animals, vegetables, and minerals cannot but strike the eye even of the most superficial observer. Though the same general laws appear to pervade the material universe, so far as our observation extends, yet these laws are so comprehensive and so endlessly modified as to produce an immense variety of minute and wonderful effects. It is more difficult to trace the operation of these laws in the remote spaces of the universe than in our terrestrial sphere. But even in regions of creation immeasurably distant we can perceive the agency of the same powers which are at work in conducting the movements of our planetary system; and not only so, but we can trace these powers, while operating with their native energy, wonderfully modified, and producing effects altogether different from those which we experience in the system of which we form a part, evidently indicating that a *variety*, analogous to that which we behold in the scene around us, marks the operations of the Creator throughout the immensity of his works. This will more clearly appear in the descriptions we shall now give of the phenomena of double and multiple stars.

The phenomena of double stars do not seem to have been much attended to till Sir W. Herschel commenced his extensive observations on the sidereal heavens. About a century ago, the astronomers of that period seem to have been aware that "several stars which appear single to the bare eye are by the telescope discovered to be double." The principal stars of this description which they mention are, the head of Castor, the first in the head of the Ram, the star *Gamma* in the breast of Virgo, and the middle one in the sword of Orion. Conceiving the fixed stars as bodies precisely of the same na-

ture, and that no specific or diversified arrangements prevailed among them, they do not appear to have entered upon any minute surveys, by the telescope, of particular stars; and their idea respecting the double stars they had detected was merely this, that a small star, at a very remote distance from another, might happen accidentally to lie nearly in the same line of vision as the larger one; and, on this ground, Dr. Long, in his "Astronomy," shows how the annual parallax would be discovered by a star appearing single at one time of the year, and double at another. It appears to have been chiefly with an object of this kind in view that Sir William Herschel commenced his numerous observations in this department of sidereal investigation. But, as we are informed by his son, who has distinguished himself in an eminent manner by similar observations, he had hardly entered on the measurement of the angles of position and the distances of double stars, before he was diverted from the original object of his inquiry by phenomena of a very unexpected character, which at once engrossed his whole attention. The circumstances alluded to shall be particularly described in the sequel, after I have given a brief sketch of the phenomena of double stars.

When a telescope of considerable power is directed to certain stars which appear single to the naked eye, another star, generally much smaller than that which appears to the unassisted eye, is seen quite adjacent to it, and in some cases the interval between the two stars is so small that it requires a very high degree of light and magnifying power to be able to perceive that they are two distinct bodies. Only a few, perhaps not exceeding six or eight, of these stars were known to the astronomers of the age preceding that of Herschel; but this illustrious astronomer, with unwearied perseverance, detected no less than 500 double stars, and presented to the Royal Society a list in which their situation and relative positions are distinctly marked. These observations of the elder Herschel were followed up by other observers, particularly by Sir J. Herschel and Sir James South, who, in the year 1824, soon after Sir W. Herschel had ceased from his labours, produced a catalogue of 380 double stars, whose distances and angles of position they had determined with the utmost accuracy and precision. Sir J. South afterward produced a *distinct* catalogue of 480, and Sir J. Herschel a list of upward

of 3300 of double and triple stars, from his own solitary observations, accompanied with all the micrometrical measurements. Struve, the celebrated astronomer of Dorpat, has arranged a catalogue of no less than 3000 double stars; and before he determined the characteristics of each of these, he examined about 120,000 stars; a laborious process, which none but an astronomical observer can duly appreciate. Mr. Dunlop has formed a catalogue of 250 double stars in the *southern* hemisphere; and Sir J. Herschel, during his late residence at the Cape of Good Hope, has added considerably to their number; so that we may now reckon about 6000 of these interesting objects as having already been discovered, even making allowance than many of these objects are common to the lists of the observers now specified.

It is not at all improbable that the phenomena of some of the double stars now alluded to may arise from *accidental proximity*, the one star, though far remote and unconnected with the other, lying nearly in the same visual line. Thus, the star *a*, figure 13, might appear nearly in contact with the star *b*, placed at an immense distance beyond it, when viewed nearly in the same straight line by the eye at *c*, so as to produce the phenomenon of a double star at *d b*. But,

Fig 13.

reasoning *à priori*, it appears in the highest degree improbable that such coincidences should happen in the case of all, or even of the greater part of the double stars which have now been discovered; and therefore Mr. Michell, so early as the year 1783, in a paper inserted in the "Philosophical Transactions" for that year, states it as his opinion that they are binary systems intimately connected. "The very great number of stars," says he, "that have been discovered to be double, treble, &c., particularly by Mr. Herschel, if we apply the doctrine of chances, as I have done in my 'Inquiry into

the probable Parallax of the Fixed Stars,' published in the Philosophical Transactions for 1767, cannot leave a doubt with any one properly acquainted with the force of those arguments, that by far the greatest part, if not all of them, are systems of stars so near each other as probably to be liable to be affected sensibly by their mutual gravitation; and it is therefore not unlikely that the periods of the revolutions of some of these about their principals may some time or other be discovered."

The prediction here announced by this ingenious gentleman has now been fully realized by Sir William Herschel and other astronomers, and is no longer a subject of conjecture, but *an ascertained fact*. This is the discovery to which I have alluded above, one of the most important and interesting discoveries which astronomy has unfolded during the present age, and which opens to our view a new prospect of the plans and arrangements of Infinite Wisdom.

Having made these preliminary remarks, I shall now proceed to a more particular detail of the facts which have been ascertained respecting binary systems.

When Sir W. Herschel first directed his attention to this subject, in order, if possible, to determine the annual parallax, he was not a little surprised that, instead of finding, as he expected, a regular annual change of the two stars, by one alternately shifting its position with respect to the other, which a parallax would have produced, he observed in many instances "*a regular progressive change*, in some cases bearing chiefly on their distance, in others on their position, and advancing steadily in one direction, so as clearly to indicate either a real motion of the stars themselves, or a general rectilinear motion of the sun and whole solar system, producing a parallax of a higher order than would arise from the earth's orbital motion." In an elaborate paper on this subject, read before the Royal Society, June 9, 1803, he considers specifically all the motions and combinations of motion that can possibly be supposed, in order to account for the phenomena, particularly of the double star *Castor*, and satisfactorily demonstrates that nothing but the idea of the smaller star revolving around the larger in a circular or elliptical orbit will solve the phenomena in question; and this conclusion has been amply confirmed by all succeeding observations. Such stars, therefore, must be considered as *physically connected* by the law

of mutual gravitation, so that they describe orbits around each other and around their common centre of gravity, and bear a relation to each other similar to that which the planets bear to our sun.

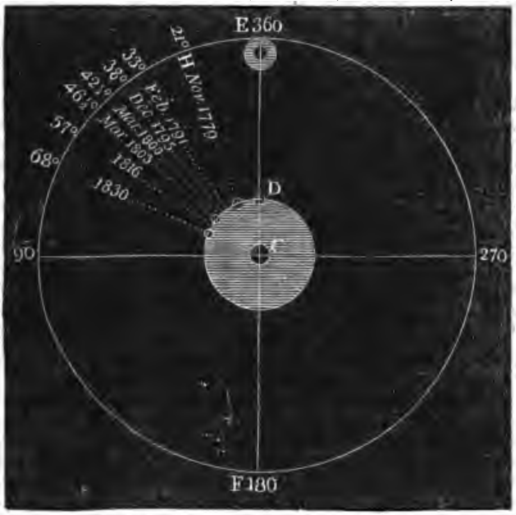
From the paper of Sir W. Herschel now referred to, I shall select, as a specimen of the motions of double stars, some of his observations of *Castor*, or *a Geminorum*. It appears that Dr. Bradley, in the year 1759, had observed the position of the two stars which form this double star, and communicated it to Dr. Maskelyne, who made a memorandum of it, of which the following is a copy: "Double star Castor. No change of position of the two stars; the line joining them at all times of the year, *parallel to the line joining Castor and Pollux* in the heavens, seen by the naked eye." The object of Dr. Bradley in observing the exact position of these stars was to determine if any change happened in their position at opposite periods of the year so as to indicate an annual parallax. The angles of position observed by Sir W. Herschel are as follow:

Times of the Observations.	Angles of Position.
November 1, 1759	56° 32′
November 5, 1779	35 29
February 23, 1791	23 36
December 15, 1795	18 32
March 26, 1800	14 3
December 31, 1801	12 12
February 28, 1802	12 1
March 27, 1803	10 53

From these observations, it appears that, from the year 1759, when Dr. Bradley observed the positions of these two stars, to the year 1803, there has been a portion of an orbit described by the smaller star around the greater equal to forty-five degrees and thirty-nine minutes; and from the time that Herschel commenced his observations in 1779 till 1803, an arc of twenty-four degrees and thirty-six minutes had been passed over. Hence Sir W. Herschel concludes; "The time of a periodical revolution may now be calculated from the arch 45° 39′, which has been described in 43 years and 142 days. The regularity of the motion gives us great reason to conclude that the orbit in which the small star moves about Castor, or, rather, the orbits in which they both move round their com-

mon centre of gravity, are nearly circular and at right angles to the line in which we see them. If this should be nearly true, it follows that *the time of a whole apparent revolution of the small star round Castor will be about 342 years and two months.*" This subject may be illustrated to the general reader by the following diagram:—

Fig. 14.



Let the small central circle C represent the larger star Castor, and D the smaller star, and let the line E F represent the direction of the two stars in a line with the star *Pollux* at E, as observed by Dr. Bradley in 1759. In November, 1779, they were found in the position C H, twenty-one degrees from the position they occupied twenty years before; in February, 1791, they were thirty-three degrees from the same position, &c.; and in March, 1803, forty-six and a half degrees, giving evident indication of a regular progressive mo-

tion in a circle. Since 1803 its motion has been regularly traced by Struve, Sir J. Herschel, and Sir J. South; and in 1816 it was found about 57° from its first position, and in 1830 about 68°, still regularly progressing. In 1819 the distance of the small star from Castor was five seconds and a half, and in 1830 it was little more than four seconds and a half. Although Sir W. Herschel, as above stated, conjectured the period of revolution to be about 342 years, yet later astronomers, from a comparison of all the observations recently made, are disposed to conclude that its period is little more than 250 years.

More than fifty instances of changes in the angles of position of double stars were observed by Sir W. Herschel, besides those which have been more recently observed by his son and other astronomers, most of which indicate motions which are regularly *progressive;* but a considerable number of years must elapse before their periods can be determined with any degree of accuracy. The following double stars are considered as demonstrative instances of circular progressive motion: γ Virginis, ξ Ursæ Majoris, 70 Ophiuchi, σ and η Coronæ, ξ Bootis, η Cassiopeiæ, γ Leonis, ζ Herculis, δ Cygni, μ Bootis, ε 4 and ε 5 Lyræ, λ Ophiuchi, μ Draconis, ε Bootis, and ζ Aquarii. The periodic times of some of these have been determined to a near approximation. One of the stars of *Gamma* Virginis is reckoned to revolve about the other in the space of 629 years; the small star of *Gamma* Leonis in 1200 years; the star connected with *Epsilon* Bootis in 1600 years; that of 61 Cygni in 452 years; that of *Sigma* Coronæ in 287 years; that of 70 Ophiuchi, as ascertained by Professor Encke, in 80 years; that of *Xi* Ursæ in 58 years; that of *Zeta* Cancri in 55 years; and that of *Eta* Coronæ in 43 years.

A whole revolution of some of these stars has been nearly completed since observations began to be made on such objects. The motion of the small star of *Xi* Ursæ began to be traced about the year 1781; in 1819 it had moved 219° from its position in 1781; in 1830 it was 303° from that position, progressing in a circle; and about this time, or the beginning of 1840, it has probably finished its orbital revolution. The star *Eta* Coronæ, whose period is forty-three years, has not only accomplished a complete revolution, but is actually considerably advanced in its second period. Sir

J. Herschel, during his late sojourn at the Cape of Good Hope, is said to have discovered in the southern skies binary stars, whose periods of revolution are even shorter than those now stated, their change of position having been quite perceptible during the three or four years of his residence in that quarter. Sir W. Herschel, in the paper to which I have already referred, states observations which furnish us with a phenomenon which is new in astronomy, namely, *the occultation of one star by another.* With a power of 460, in July, 1782, the stars of *Zeta* Herculis were then half the diameter of the small star asunder; in 1795 he found it difficult to perceive the small star with the same power; in 1802 the small star could no longer be perceived, but the apparent disc of the large star seemed to be a little lengthened one way. With his ten feet telescope, and a power of 600, he found it to have the appearance of a wedge-formed star. On the 11th of April, 1803, he examined the apparent disc with a power of 2140, and found it, as before, a little distorted, but there could not be more than about three fourths of the apparent diameter of the small star wanting to a complete occultation. "Most probably," he observes, "the path of the motion is not quite central; if so, the disc will remain a little distorted during the whole time of the conjunction." This phenomenon evidently demonstrates the fact of circular orbital motion, performed in a plane nearly parallel to our line of vision.

The star *Gamma* Virginis has presented phenomena nearly similar to that of *Zeta* Herculis. This star is remarkable both for the length of its period, the rapid increase of the angular motion of the two stars of which it is composed, and particularly *the great diminution of their apparent distance.* It has been known as a double star for at least 120 years. The two stars of which it is composed, and which are nearly equal, were so far apart about the middle of the last century that they were marked in Mayer's catalogue as two distinct stars, so that any moderately good telescope would have shown their separation, being at that period about seven seconds distant from each other. Since that time they have been constantly approaching, and in 1833 were scarcely more than a single second asunder; so that a common telescope was insufficient to show their separation, and even telescopes of very superior power could show them no otherwise than as a single star somewhat elongated. According to Sir J.

Herschel's computations, the small star must have arrived at its perihelion on the 18th of August, 1834. He also determined *the inclination of the orbit to the visual ray* to be 22° 58′, and *the angle of position of the perihelion* projected on the heavens 36° 24′. The small star of *Eta* Coronæ reached its perihelion in 1835; and it is calculated that the revolving star of Castor will reach the same point during the year 1855.

From the observations that have been made on binary stars, it now appears demonstrable that the law of gravitation extends its influence to the starry regions; that the same laws of motion which direct the planets in their courses, and connect them with the sun as their centre, likewise operate in these binary systems in carrying one star around the centre of gravity of another. It has often been surmised that gravitation is a power which is universal in its influence; and here we have a proof that it extends not only beyond the range of the planetary system and the orbits of the most eccentric comets, not only to stars reckoned the nearest to our globe, but to those of the third, fourth, and even tenth magnitudes, which may be supposed many hundreds of billions of miles farther distant; thus rendering it highly probable that it is a fundamental law of matter, and extends its energies throughout the amplitude of creation, combining in one vast system all the operations of the Eternal.

The orbits in which the one star moves around the other are found to be *elliptical*, which is the same kind of curve in which the earth and the other planets move round the sun, and in which the satellites of Jupiter, Saturn, and Uranus perform their revolutions round their respective primaries; another proof that the same general law operates in both cases. Some of these orbitual motions are *retrograde* and others are *direct*, or in the same direction as the motions of the planets of our system. In some cases it happens that the edge of the orbit of the revolving star is presented to the earth, or in a line parallel to that of our vision, as is found in the star π Serpentarii; in which case the star appears to move in a straight line, and to oscillate on each side of the larger star around which it revolves, in a manner similar to that of the satellites of Jupiter, which appear to pass from the one side to the other of the planet in nearly straight lines, because the plane of their orbits is nearly in a line with our eye. At the time when Sir W. Herschel first observed this binary system,

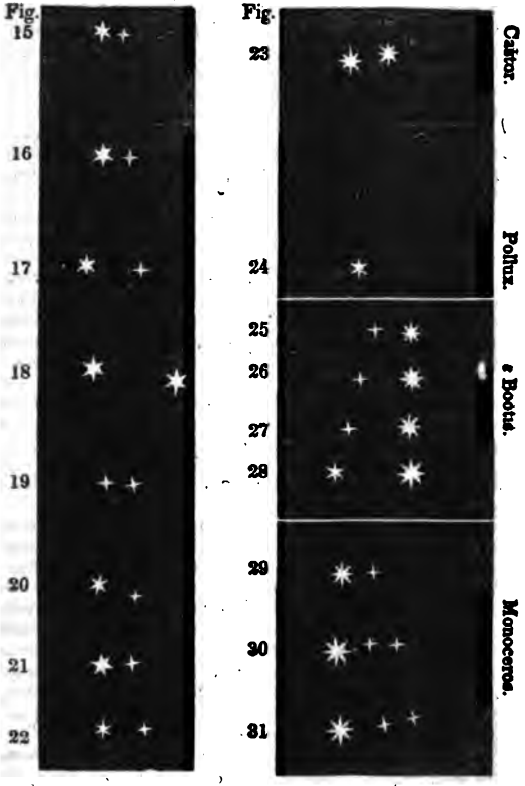
the two stars were distinctly separate; but at present the small star is so completely projected on the other that even Struve, with his powerful telescope, cannot now perceive the least separation between the two bodies; a fact which evidently demonstrates that to our eye the one is passing across the disc of the other, and that a number of years hence it will appear on the other side of the larger star. On the other hand, the two stars of *Zeta* Orionis are now separated by a small interval, although they appeared as one star in the time of Sir W. Herschel; all which phenomena demonstrate a motion in a circular or elliptical orbit, the plane of which lies *oblique* to our eye; and it has been calculated, from the apparent motions of these bodies, that the ellipses in which they move are in general more elongated than the orbits of the solar planets. On the whole, to use the words of Sir John Herschel, "we have the same evidence of their rotations about each other that we have of those of Uranus and Saturn about the sun; and the correspondence between their calculated and observed places in such very elongated ellipses must be admitted to carry with it proof of the prevalence of the Newtonian law of gravity in their systems, of the very same nature and cogency as that of the calculated and observed places of comets round the central body of our own."

Having stated the above general facts respecting binary stars, I shall now present to the reader a few telescopic views of these objects.

Fig. 15 represents a telescopic view of *Epsilon* Bootis, with a magnifying power of about 200 times. This is reckoned a very beautiful double star, on account of the different colours of the stars of which it is composed, and has an appearance somewhat similar to a planet and its satellite, both shining with innate but differently coloured light. The small star is of a bluish colour, and is separated from the other by a space equal to the diameter of the larger star, and its apparent size is one third of the other. It is sometimes called *Mirac*, and is situated about ten degrees northeast of *Arcturus*. The large star has a *reddish* tinge.

Fig. 16 is *a* Herculis: the small star is of a bluish colour, separate from the other two diameters of the large star; the blue star is one third the size of the other. It is situated in the head of Hercules, about thirty degrees southwest from the bright star *a* Lyræ, and six degrees northwest from *Ras*

Fig. 15—31.



Alhague, a star of nearly the same magnitude. It comes to the meridian about the middle of July, at nine o'clock in the evening, at an elevation of about fifty-two degrees. This

star is also distinguished by the name *Ras Algethi*, and may be seen marked in Plate II., which contains a map of stars which are seen near the meridian about the beginning of September.

Fig. 17 is a view of γ Andromedæ: the small star is of a fine greenish-blue colour, separate from the large star about nine seconds, or four diameters of that star; the larger star is of a reddish white. It is situated in the left foot of Andromeda, and is distinguished by the name of *Almaack*. It is a star of the second magnitude, about forty-two degrees of north declination, and passes the meridian, in the beginning of December, about half past ten in the evening, about ten degrees south from the zenith. It is about twelve degrees nearly due west from the variable star *Algol*.

Fig. 18 is *Zeta* Cygni: the smaller star is blue, and they are separated about ten diameters. This star is situated in the eastern wing of the Swan; right ascension, 21h 4', north declination twenty-eight degrees, and is about twenty degrees southeast of Denib, the principal star of this constellation.

Fig. 19 represents *Zeta* Aquarii. The two stars are nearly equal in apparent magnitude, and one diameter and a half separate from each other; both stars are of a whitish colour. It is in the middle of other three stars, which together form a figure resembling the letter Y. Its right ascension is 22h 20', and its south declination about two degrees. It is a star of about the third magnitude, and comes to the meridian at nine o'clock in the evening about the middle of October.

Fig. 20 represents the *Pole-star*. The accompanying star is a very faint point, and requires an accurate telescope with considerable power to distinguish it.* The large star is white, and the small star somewhat of a ruddy appearance, and is distant from the larger seventeen seconds, or about three or four of its diameters.

Fig. 21 is the double star *Castor*. The smaller star is nearly half the size of the larger, and they are distant about five seconds, or two diameters of the principal star. They are both of a whitish colour. Their situation may be found on Plate I. Castor and Pollux lie to the northwest of Orion at a considerable distance from it. They are very conspicuous, are within five degrees of each other, and rise to a very

high elevation when passing the meridian, and may be seen throughout the whole winter and spring months. *Castor* is the more elevated of the two.

Fig. 22 represents *Rigel*, a splendid star in the left foot of Orion. The small star is a mere point, and very difficult to be distinguished, and is three or four-diameters of the large star from it. The large star is white, the small one of a reddish hue.

Fig. 23 shows the double star Castor, with a magnifying power of 300. It likewise shows the angular position of the small star at the present time in respect to *Pollux* (fig. 24), by which it appears that it is nearly at a right angle to a line joining Castor and Pollux, whereas in the time of Dr. Bradley it was *parallel* with a line joining these two stars.

Fig. 25, 26, 27, and 28, exhibit views of the double star *Epsilon* Bootis, with four magnifying powers. Fig. 25 is its appearance with a power of 227; fig. 26, with a power of 460; fig. 27, with a power of 900; and fig. 28, with a power of 1100.

Fig. 29, 30, and 31 represent telescopic views of the triple star in the left fore foot of the constellation *Monoceros*, or the Unicorn, which forms a very beautiful object in this class of stars. This star appears at first double, but with some attention one of the two is discovered to be also double; the first of them is the largest. The colour of all these stars is white. With a small power they appear as in fig. 29; with a power of 220, as in fig. 30; and with a power of 450, as in fig. 31. There is a beautiful object of this description, but somewhat different in the configuration of the three stars of which it is composed, to be seen in the tail of the Great Bear; it is the star *Zeta* Ursæ, called also *Mizar*, and is the middle star in the tail.

Such are a few specimens of the telescopic appearances of this class of celestial objects. Some of these objects, in order to be distinctly seen, require telescopes of considerable magnifying power. All the objects, however, referred to above may be seen with a good three feet and a half achromatic telescope, whose object glass is two inches and three quarters aperture. The double star Castor may be seen with powers of 80, 140, and 180. I have frequently distinguished the separation of the two stars with a terrestrial power of only 45; but the higher powers, of course, are much preferable

In order to perceive the very small star or point of light adjacent to the Pole-star, a power of 140 at least is requisite with such a telescope; but it is more distinctly seen with a power of 190 or 200. It is considered as a fair test of the goodness of a telescope of this description when this minute object is perceptible with such powers. The small star connected with *Epsilon* Bootis is likewise an object which requires a considerable degree of magnifying power and distinctness to perceive the separation of the two stars; and it is more difficult to perceive the small star adjacent to *Rigel* than any of these objects.

In the phenomena I have now described, we have a new and interesting scene presented before us, which leads the mind into a train of thought very different from what could have been conceived by astronomers of a former age. To some minds, not accustomed to deep reflection, it may appear a very trivial fact to behold a small and scarcely distinguishable point of light immediately adjacent to a larger star, and to be informed that this lucid point revolves around its larger attendant; but this phenomenon, minute and trivial as it may at first sight appear, proclaims the astonishing fact, that SUNS REVOLVE AROUND SUNS, AND SYSTEMS AROUND SYSTEMS. This is a comparatively new idea, derived from our late sidereal investigations, and forms one of the most sublime conceptions which the modern discoveries of astronomy have imparted. It undoubtedly conveys a very sublime idea to contemplate such a globe as the planet Jupiter—a body thirteen hundred times larger than the earth—revolving around the sun, at the rate of twenty-nine thousand miles every hour; and the planet Saturn, with its rings and moons, revolving in a similar manner round this central orb in an orbit five thousand six hundred and ninety millions of miles in circumference. But how much more august and overpowering the conception of a sun revolving around another sun, of a sun encircled with a retinue of huge planetary bodies, all in rapid motion, revolving round a distant sun, over a circumference a hundred times larger than what has been now stated, and with a velocity perhaps a hundred times greater than that of either Jupiter or Saturn, and carrying all its planets, satellites,

comets, or other globes along with it in its swift career! Such a sun, too, may as far exceed these planets in size as our sun transcends in magnitude either this earth or the planet Venus, the bulk of any one of which scarcely amounts to the thirteen hundred thousandth part of the solar orb which enlightens our day. The farther we advance in our explorations of the distant regions of space, and the more minute and specific our investigations are, the more august and astonishing are the scenes which open to our view, and the more elevated do our conceptions become of the grandeur of that Almighty Being who "marshalled all the starry hosts," and of the *multiplicity* and *variety* of arrangements he has introduced into his vast creation. And this consideration ought to serve as an argument to every rational being, both in a scientific and a religious point of view, to stimulate him to the study of the operations of the Most High, who is "wonderful in counsel and excellent in working," and whose works in every part of his dominions adumbrate the glory of his perfections, and proclaim the depths of his wisdom and the greatness of his power.

In order to form a comprehensive conception and a proper estimate of such binary systems, we have to consider, in the first place, the distances of the stars or *suns* from each other. These distances, in the mean time, cannot be accurately ascertained till something more definite be determined respecting the parallaxes of these bodies. Some have supposed that the distance between some of these binary stars may be as great as the distance between the earth and any of these stars. But such a supposition is highly improbable if we admit, what is now completely ascertained, that these bodies are intimately connected by the law of gravitation. Their distance, however, must be very great, notwithstanding their apparent nearness to each other, as a few seconds of interval, at the distance of the nearest star, must comprise an immense space. I shall suppose this distance in the case of some of these bodies to be only the one hundredth part of what is reckoned the distance (namely, twenty billions) of the nearest star. On this supposition, the distance of the revolving star from its primary would be 200,000,000,000, or two hundred thousand millions of miles. The circumference of its orbit would therefore be 1,256,640,000,000 of miles. The small star of ξ Ursæ completes its revolution in fifty-eight years, and, conse-

quently, if at the distance now supposed from its primary, must move at the rate of two millions four hundred and seventy-one thousand miles every hour, which is eighty-five times the velocity of the planet Jupiter, and more than twenty-three times the velocity of Mercury in its orbit, which is the swiftest moving planet in our system. This motion would be still more swift in the case of some of the other stars to which we have alluded. The small star of 6 *Eridani*, as determined by Mr. Dunlop, revolves around the larger at the rate of somewhat more than ten and a half degrees per annum, and consequently accomplishes a revolution in little more than thirty years. Its motion, then, at the distance supposed, would be equal to four millions seven hundred thousand miles an hour, which is 162 times the velocity of Jupiter, and about 44 times that of Mercury. Even the small star of γ Leonis, which takes 1200 years to accomplish its revolution, would, on the same supposition, move at the rate of 119,000 miles an hour, which is a greater velocity than that of the swiftest planets of our system. These are immense velocities, especially when we consider the enormous size of the bodies thus impelled; for the least of these suns may be considered as *ten millions* of times larger than the planet Mercury, yet moving with a velocity so much superior.

What, then, would be the velocities of such bodies, were we to suppose them as far distant from each other as we are from the nearest star! In the case of *Xi* Ursæ, the velocity would be two hundred and forty-seven millions, one hundred and sixty thousand miles every hour, and four millions, one hundred and fifty thousand every minute; and in the case of 6 *Eridani*, the velocity would be 477,800,000 miles an hour, and 132,735 in a *second*, which is more than sixteen thousand times the velocity of Jupiter. That bodies may move with such velocities is perhaps not impossible, but it is highly improbable that such rapid motions actually exist among bodies of such astonishing magnitudes; and therefore we must suppose that the binary stars are within a moderate distance of each other. Still that distance must be very considerable, and, it is not unlikely, may be as great as I have supposed; and, if so, it presents to our view motions more rapid and sublime than any which are known to exist within the limits of our planetary system.

In the next place, we must consider the *system of planets*

connected with the binary stars. These stars are evidently suns or self-luminous bodies, otherwise their light would never reach our distant sphere. But we can never admit that suns were created merely to diffuse a useless splendour over the waste spaces of infinity, where there are no sentient beings with visual organs to be cheered with their radiance. In this case they might be said to be created in vain. Hence we must necessarily conclude that these suns are attended with a retinue of planetary bodies, which revolve around them as the centres of light and attractive influence, and we can scarcely conceive a more sublime and astonishing object than that of magnificent suns revolving around still more magnificent and luminous centres, and conveying along with them in their swift career a numerous train of mighty worlds, all in regular and rapid motion, around their respective orbs. In such sublime sidereal arrangements we behold a combination of motions and effects of gravitation which are not to be traced throughout any part of the system to which we belong. For while the planets which perform their revolutions around the revolving sun are affected by the power of attraction from that body, with which they are more immediately connected, they must likewise be attracted by the larger central sun, and their motions sometimes retarded, sometimes accelerated, and variously modified, by its powerful influence, which combined influences must produce a diversity of phenomena and effects unknown in the system of our sun. For the sake of some readers, not accustomed to such views and contemplations, I have given a rude sketch of a binary system in fig. 32, in which the central circles represent the larger sun with its attendant planets, and the other circles the revolving sun and its planets, in four different positions.

Again, in contemplating these binary systems, we perceive a great diversity in the periods of their revolutions. The period of revolution of the small star of ε Bootes is calculated to be not less than 1600 years. An inhabitant of that system would be considered by us an old residenter were he to survive the period of a year, or a single revolution. But in such systems it is not likely that the lapse of duration is marked by so short periods as in our own sublunary abode, nor is it probable that disease and death cut short the existence of its inhabitants, as in the world in which we dwell. Another of these suns takes 1200 years to complete a revolution; an-

other, 629 years; and another, 452; while several others finish their circuits in the comparatively short periods of 55, 43, and even 30 years. Whether these diversities in the periods of revolution be owing to the different magnitudes of the respective bodies, their distances from each other, the amplitudes of the orbits in which they move, or the comparative velocities with which they are carried forward in their career, we have as yet been unable to determine; and a long-continued series of the most delicate and minute investigations is still requisite before such points can be ascertained with any degree of precision. But such striking differences in their periodic revolutions evidently indicate that the characteristic of *variety* is impressed upon all the arrangements connected with those distant systems; which leads us to conclude that there is no system of suns or worlds in the universe exactly resembling another, although they may be all subject to the same general and fundamental laws. From such circumstances we are likewise led to infer, that among bodies in the more distant regions of creation there may be motions and arrangements altogether different from anything we yet know, which produce scenes of beauty, sublimity, and grandeur far surpassing what the mind of man can yet conceive.

In regard to the *number* of such binary systems, no precise estimate has yet been made. We have, however, every reason to believe that their number is very great. I have already stated that about 6000 double stars have been detected by M. Struve, the two Herschels, Mr. Dunlop, and Sir James South. On the doctrine of chances, it is in the highest degree improbable that the greater part, or even any considerable number of these bodies, appear double by their accidental proximity, or being so placed one behind another as to be nearly in the same line of vision. We may therefore conclude that at least 4000 of these stars are binary systems connected by the law of mutual gravitation. Between forty and fifty of these bodies have been ascertained beyond doubt to form revolving systems, and time must be allowed for farther investigations. It is but lately that the attention of astronomers has been directed to such observations; and on account of the very minute distances of the revolving stars from each other, and the slight variation of the angle of position which can be traced for a series of years, an age or two is requisite in order to determine with precision the de-

gree or progress of their revolutionary movements. Some of their orbits, too, may be so extensive, or their motions so comparatively slow, that several thousands of years may elapse before the periods of some of these bodies be completed; and if so, we have no reason to conclude that they are *not* binary systems, although half a century should elapse without any change being perceived in their angular positions. In the course of fifty or sixty years hence, we have reason to believe many important discoveries will be made in reference to the bodies in question, and what is at present doubtful or obscure will be rendered definite and precise. In the mean time, we may safely take for granted that several thousands of those revolving suns and systems lie within the range of our telescopes, whose revolutions will ere long be determined. But as our most powerful instruments can carry us only a very small way, comparatively, beyond the outer boundaries of those mighty heavens which surround us, ten thousands of such systems may exist in those remoter regions which will for ever remain inexplorable by mortals.

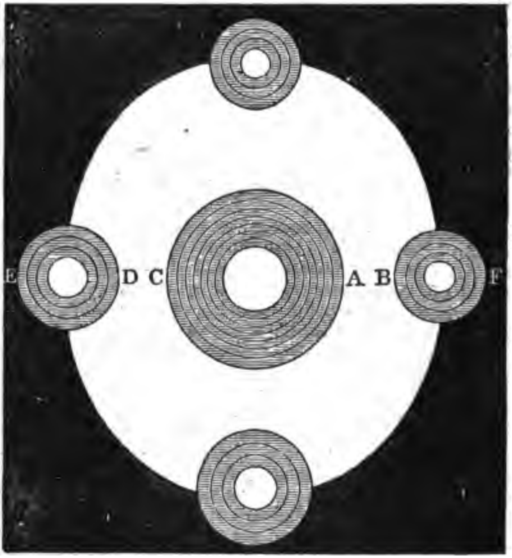
There is another interesting view which may be taken of these binary systems, and that is, *the contrast of colours which some of the stars composing these systems exhibit.* I have already alluded to some of these stars being of different colours, and any observer who is possessed of a good telescope may easily satisfy himself on this point. "Many of the double stars," says Sir J. Herschel, "exhibit the beautiful and curious phenomena of contrasted or complementary colours. In such instances, the larger star is usually of a ruddy or orange hue, while the smaller one appears blue or green; probably in virtue of that general law of optics which provides that when the retina is under the influence of excitement by any bright-coloured light, feebler lights, which, seen alone, would produce no sensation but of whiteness, shall for the time appear coloured with the tint complementary to that of the brighter. Thus a yellow colour predominating in the light of the brighter star, that of the less bright one in the same field of view will appear blue; while if the tint of the brighter star verge to crimson, that of the other will exhibit a tendency to green, or even appear as a vivid green under favourable circumstances. The former contrast is beautifully exhibited by *Iota Cancri*, the latter by *Gamma* Andromedæ, both fine double stars. If, however, the coloured star be much the

less bright of the two, it will not materially affect the other. Thus, for instance, *Eta* Cassiopeiæ exhibits the beautiful combination of a large white star and a small one of a rich ruddy purple. It is by no means, however, intended to say, that in all such cases one of the colours is a mere effect of contrast; and it may be easier suggested in words than conceived in imagination, what variety of illumination *two suns*, a red and a green, or a yellow and a blue one, must afford a planet circulating about either; and what charming contrasts and 'grateful vicissitudes'—a red and a green day, for instance, alternating with a white one and with darkness—might arise from the presence or absence of one or other, or both, above the horizon. Insulated stars of a red colour, almost as deep as that of blood, occur in many parts of the heavens, but no green or blue star (of any decided hue) has, we believe, ever been noticed unassociated with a companion brighter than itself."

The fact of *coloured suns*, of suns belonging to the same system diffusing light of opposite or contrasted colours, presents a novel and interesting idea, and a splendid scene, in which a lively imagination may luxuriate while depicting the diversity of aspects under which objects will appear in those worlds which are alternately illuminated by such a variety of irradiation. It is somewhat difficult, however, to form a distinct conception of the peculiar beauties, sublimities, and contrasts, which will be produced by such admirable arrangements. We are unacquainted with the nature and qualities of the substances which are thus illuminated, and therefore cannot determine the peculiar hues of splendour which will result from the reflection of such irradiations; but we may easily conceive there will be a considerable difference in the variety and splendour of such illuminations, and in the contrasts of colours which will be exhibited when the revolving planets are in different parts of their orbits. When in such positions as *A B C D* (fig. 32), they will be more directly under the influence of both suns than when at *E* and *F*, and, of course, the effects of the contrasted coloured rays will be most remarkable. One hemisphere of a planet may be illuminated with a yellow sun, while the other is at the same time enlightened by a green, and both suns may occasionally shine in the same hemisphere, producing such a blending of hues and a contrast of colouring over the whole landscape, as to render

the aspect of the scene completely different at one time from what it is at another. In different parts of the planets' courses around their primary suns, these effects will be variously modified, so as to produce an almost perpetual variety in the scenery of such worlds. A sun of a brilliant white colour

Fig. 32.



may perhaps be seen rising, while a sun of a ruby hue is descending below the horizon; and when both suns are absent, the starry firmament will appear in all its splendour, and every object around present a contrast to its previous appearance.

The science of optics, and particularly the experiments which have been made on *polarized light*, show us what a variety of combinations of vivid and beautiful colours may be produced by certain modifications of light, which may easily

lead us to conceive of the sublime and diversified brilliancy of colouring which must be the result of the irradiation of suns of different hues. The light of the stars in general is greatly diversified, although, on a cursory view of the firmament, they appear nearly of the same aspect. The rays of *Sirius*, for example, are not only strikingly different from those of *Aldebaran*, but from those of many other stars which seem to bear a nearer resemblance. In tropical climates, where the sky is clearer than with us, and almost of a dark ebony colour, the different hues of the stars are more striking and perceptible to the naked eye than when seen through our comparatively hazy atmosphere. In this respect, then, as well as in several others, the declarations of the inspired writer is literally true, that "one star differeth from another star in glory." Milton, in the eighth book of his "Paradise Lost," utters a sentiment on this subject which seems to be almost prophetic, when he represents Raphael in his address to Adam as saying,

> "Other suns, perhaps,
> With their attendant moons, thou wilt descry
> *Communicating male and female light,*
> Which two great sexes animate the world,
> Stored in each orb, perhaps, with some that live."

In these phenomena we have another proof of the infinite *variety* which the Creator has introduced into the systems of the universe, a variety in regard to *colour* as well as to magnitude, motion, and other arrangements, which leads us to conclude that, although we were permitted to make the tour of universal nature, we should meet with no worlds or systems of worlds in which the scenery and arrangements are exactly the same, but that each would display its own peculiar harmonies, beauties, and sublimities, and the enraptured spectator, at every stage of of his excursion, would behold a new manifestation of "the manifold wisdom of God."

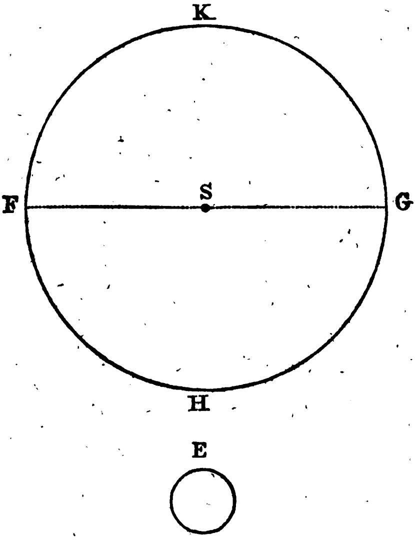
It would be an important and interesting acquisition in astronomy could we determine exactly, or even to a near approximation, the *distances* of any of these binary systems, and the *actual dimensions* of the orbits of the revolving stars. It appears, from what has been formerly stated (p. 60–68), that the parallax, and, consequently, the distance, of 61 *Cygni* has been determined by Professor Bessel. Now this is a double star or binary system, and one of the stars is found to have an annual angular motion of about two thirds of a de-

gree; from which it is inferred that the period of its revolution may be about 450 years, and that the semi-major axis of its orbit is seen under an angle of more than 15″. Were these and other correlative points accurately settled, we might soon determine to a near approximation the extent of its orbit, the space through which it moves in the course of a revolution, and, consequently, its rate of velocity; but as the motion of revolution of this star is so extremely slow, a considerable period of years may elapse till all the elements of its orbit be accurately ascertained.

A few years ago, a method was pointed out by M. Savory, a French astronomer, by which the dimensions of the orbit of a revolving star might be determined. This method depends upon the fact that light moves with a certain known rate of velocity. Suppose that one of the double stars moves round another in an orbit which is nearly parallel to our line of vision, it is evident that the one half of its orbit will be nearer us than the other, and that, at the most distant point of its course, the star will be removed from us to a distance equal, or nearly equal, to the whole diameter of its orbit farther than when at the point which is nearest the earth. As the light which proceeds from the star takes a certain time in moving across the interval which separates us from that body before it reach our eye, we must necessarily see the star in a point of its orbit different from that in which it is actually placed. Let *S* (fig. 33) represent the central star, *E* the earth, and *H F K G* the orbit of the revolving star. When the star is at *H*, it is nearest the earth; and when at *K*, it is farther distant by the whole diameter of its orbit. Now, when the star proceeds from *H*, the nearest point of its orbit, its light will take a longer period to reach the earth in proportion as it moves on in its course from *H* to *G* and from *G* to *K*, and, consequently, will appear to take a longer time than in reality it does in moving along that portion of its orbit; but in returning through the other half of its orbit, *K F H*, it will appear to pass through it in a less space of time than it actually does, since the light which proceeds from it takes less and less time to reach our eye as it approaches in its course towards *F* and *H*. If, therefore, we could accurately determine the difference of time between these two half revolutions of the star, we should have *data* sufficient for determining, to a near approximation, the dimensions of the orbit in miles or other known measures;

and, having found these dimensions, the distance of the star from the earth could likewise be found by an easy trigonometrical calculation.

Fig. 22.



This method of finding the dimensions of binary systems is entitled to the praise of ingenuity; but it will be difficult, in many instances, to put it in practice. Its accuracy will depend upon our knowing the *position* of the orbit with regard to our eye, and our ascertaining exactly when the star is in *H* or at *K*, or the two opposite points of its orbit. Besides, a very long time must intervene before observations of this kind can be completed, since most of the periods that have been determined in regard to double stars extend to several hundreds of years, and the shortest period yet known of any of

these revolving bodies is above thirty years. It is generally taken for granted, by those who have adverted to this subject, that the distance between the revolving and the central star is as great, or nearly as great, as that which intervenes between us and the nearest star; and hence, in their illustrations of this point, they have supposed light to take at least one year in crossing the orbit of a revolving star, which, of course, would make the diameter of such an orbit above *six billions* of miles. But there appears no reason for forming such extravagant suppositions, as in such a case the binary stars could scarcely be supposed to have any intimate connexion. We might almost as soon suppose that the star Sirius might revolve around our sun, or the sun around Sirius. It is not likely that the double stars in general are much farther from each other than the distance I formerly supposed, namely, 200,000,000,000; and, consequently, the diameter of their orbits about 400,000,000,000 of miles. Through this space light would pass in the course of 24 days and 2⅓ hours; and therefore it would require very accurate determinations indeed of the points *H* and *K*, or the nearest and remotest points of the orbits, before any precise conclusions could be deduced, if the stars be not farther distant than I have supposed, and it is perhaps as probable that they are considerably within that distance. It is not improbable, however, that the dimensions of the orbits of some of those stars whose periods are shortest may in this way be determined; but a considerable period must elapse before the requisite observations can be made.

CHAPTER IX.

ON TREBLE, QUADRUPLE, AND MULTIPLE STARS.

Besides the combinations of double stars described in the preceding chapter, treble, quadruple, and multiple stars have been discovered, many of which appear to be intimately connected, and to be formed into regular systems, whose motions and phenomena must, of course be more diversified and com-

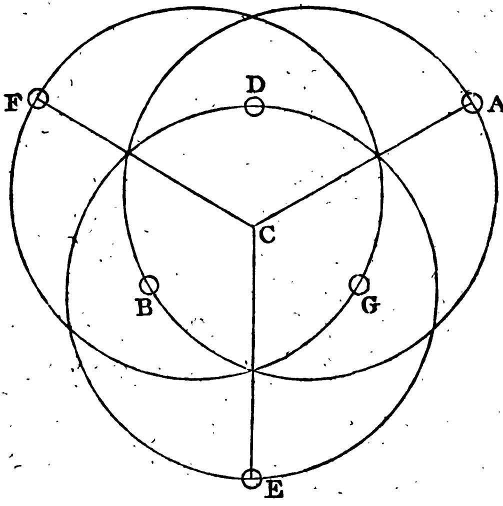
plicated than those of binary systems. Without entering into particular discussions on this subject, I shall present to the reader only two or three general remarks, with a short list of some of the treble and multiple stars to which I allude.

The more profound and minute our investigations are into the scenery of the heavens, the more do we discover of the endlessly diversified modes by which the system of universal nature is arranged and conducted, and the more clearly do we perceive a display of the infinite wisdom and intelligence of its almighty Author. Who could have previously conceived of one sun and system revolving round another, had not recent observations demonstrated the astonishing fact? As one discovery naturally leads to another, so the facts which have already been ascertained may lead to discoveries in future generations still more wonderful and sublime than those which have hitherto been brought to light. The discovery of binary systems leads to the conclusion that almost all the close groups or clustering stars visible to the naked eye or descried by telescopes are multiple systems, or suns and planetary worlds linked together by a universal law or principle, acting in different modes, and producing an immense variety of physical phenomena and effects. Guided by principles and facts recently brought to light, astronomers have only to direct their attention more particularly to such objects, to watch with care the slightest movements in the sidereal heavens, and take their measurements of distances and angular positions with the utmost precision; and then we may expect that succeeding generations will have unfolded to their view a more sublime and comprehensive prospect of the arrangements of the universe.

In certain cases, it has already been ascertained that treble stars form one connected system. The star marked ζ Cancri is a treble star of this description. Two of the stars are considerably unequal; the largest of these is larger than the single star, and the least of the two is less than the single star. The first and second largest, as described by Sir W. Herschel, are pretty unequal, and the second and third pretty unequal. The two nearest are pale red. They require very favourable circumstances to be distinctly seen; they are just separated by a power of 227, and with 460 their distance is $\frac{1}{4}$th the diameter of the smaller one. This is considered a case in which three suns revolve around a common centre. Observation has not yet afforded sufficient data for determining the particular mo-

tions or arrangements of such complex systems; but we may conceive them as arranged in a manner somewhat similar to what we have delineated in fig. 34, where the point *C* may represent the common centre of gravity around which the three bodies revolve. The circles *A B*, *D E*, *F G*, represent the

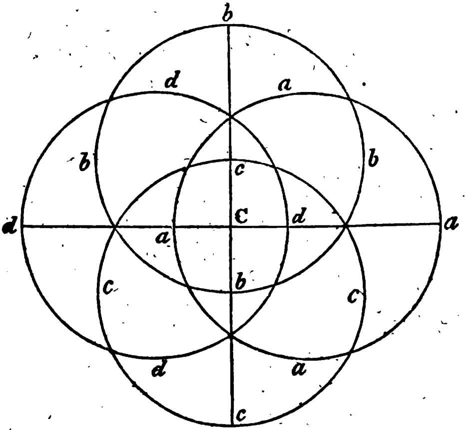
Fig. 34.



orbits of the revolving bodies, which may be conceived as lying in different planes oblique to each other, to prevent any occasional collision or too near an approach.

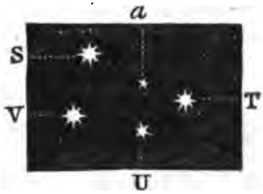
A *quadruple* system may be represented by fig. 35, where *C* is the centre of gravity round which the four bodies revolve, and the circles *a a a a*, *b b b b*, &c., the respective orbits in which they move. The star *ε* Lyræ is probably a system of this kind. It is a star of the fifth magnitude, situated about two degrees northeast from the bright star *Vega*, or *α* Lyræ.

Fig. 35.



The stars of which it is composed are easily distinguishable by a telescope of moderate power, and it is easily found from its vicinity to the very bright star adjacent to it. The small stars of which it is composed are situated nearly as represented in fig.

Fig. 36.

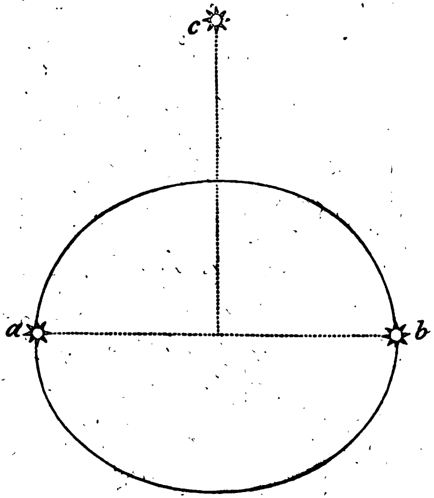


86. We might conceive of such a system of bodies revolving in a still more complex manner; the star *V* revolving round *S*,

the star *U* revolving round *T*, the system of *V* and *S* revolving round a point *a*, and the system of *U* and *T* round the same point or centre in a separate but more expansive orbit. But it is difficult to form diagrams of such complex systems.

There are many different combinations by which we may conceive treble, quadruple, and multiple stars to revolve round their common centre of gravity, which it would be too tedious to describe, particularly as such motions have not yet been accurately ascertained. Sir W. Herschel describes one of these possible combinations, which is not a little singular. Suppose two equal stars, *a* and *b* (fig. 37), moving in a circu-

Fig. 37.



lar orbit round their common centre of gravity, which will be the centre of the circle. From the centre of the circle, draw a line perpendicular to the plane of their orbit, extending to

equal distances above and below this centre. Let us now suppose a third star, *c*, to fall from one extremity of this perpendicular from a state of rest; it will obviously descend with a gradually accelerated motion till it reaches the centre of gravity; and, passing onward with a motion gradually retarded, it will move to the other end of the perpendicular, where it will arrive at a state of rest, and again return and continue to oscillate between these two points. The two stars which move in a circular orbit may describe equal ellipses of any degree of eccentricity. In this case, however, the perturbations will affect not only the planes of their orbits, but also their figures; and the length of the oscillations of the third will be sometimes increased and diminished.

A sun oscillating in a line perpendicular to the orbit of other two suns, and continuing its motion for ages in that line, is certainly a very strange idea; and yet, from the variety we perceive in the arrangements of the universe, it is not at all improbable that such combinations may exist among treble stars. The idea here intended to be conveyed may be illustrated by suspending a ring, and placing a wire perpendicular to it in its centre. The ring will represent the plane of the orbit in which the two equal stars move, and the perdendicular wire the line or course of the third star moving backward and forward with different degrees of accelerated and retarded motion. The motions connected with quintuple and multiple stars must be still more complex than those to which we have adverted; but it is difficult in the mean time to form any distinct ideas on the subject, till actual observation in the course of succeeding ages shall pave the way for deducing definite conclusions. The discoveries already made open to view new scenes of celestial mechanism, and new views of the diversified and admirable contrivances of Divine Wisdom; so that, in reference to such objects, we may apply to the almighty Architect the language of the sacred writer, "How unsearchable are thine operations, and thy ways past finding out!" When we consider that around each of these moving suns a retinue of planets must be supposed to wheel their courses, at different distances and in different periods of time, we cannot but feel astonished at the *complexity* of motions, perturbations, and other effects which must necessarily follow; yet we are bound to believe that everything moves onward, not only without confusion, but in the most perfect or

der and harmony; for He who at first arranged the plan of the material world, and impressed upon matter the laws which now operate, is possessed of boundless intelligence, and foresees at one glance all the effects which those laws can possibly produce; and, so far as our observation extends, every object and movement in nature appears to be adjusted with the most perfect regularity.

The solution of the "problem of three bodies" was considered as a work of so great nicety and difficulty, that none but such profound mathematicians as Clairaut, D'Alembert, and Euler could undertake such a delicate and laborious investigation. This problem was "to determine the curves described by three bodies projected from three points given in position, and with velocities given in quantity and direction; the force with which they gravitate being directly as their quantities of matter, and inversely as the squares of their distance." If the resolution of such a problem required so great acuteness of intellect, and so eminent skill in the science of analysis, what perspicacity of intellect, and what profound knowledge of everything connected with physical and mathematical investigations, must be requisite to determine the courses described and the perturbations produced by the complex motions of five, six, or seven suns all connected together, yet moving in different curves and in different directions, along with hundreds of planets, each connected with its own sun and pursuing its own distinct course, yet acted upon in succession with different degrees of force by the attractive influence of other suns! All our boasted powers of analysis are completely incompetent for such determinations. The faculties of an archangel, or of intelligences of a higher order than that of man, are alone adequate to such investigations; and this circumstance affords a presumptive evidence that such superior intelligences actually exist in the universe, and that man, in the present improvement of his powers, may be in the act of training for the employments and the society of such intellectual beings in a future scene of existence.

The following brief list of treble and multiple stars, selected chiefly from Sir W. Herschel's catalogue, is given for the sake of those who may be disposed to inspect them with their telescopes.*

* As the following and similar lists are inserted for the purpose of reference to amateur observers, the general reader, if he think proper, may pass over such lists and descriptions.

π, or 42 *Aries, in the ham,* sixth magnitude. The three stars, which are all in a line, are excessively unequal; the largest is white, and the two smallest are mere points. With a power of 460, the two nearest are 1½ diameter of the largest star. The third is about 25″ from the largest.

ε, or 4 or 5 *Libra.* This is a remarkable double-double star, or a double star, each star itself being a double star. The first set consists of stars that are considerably unequal. The largest is very white, and the smallest reddish. Their distance with 227 is one diameter of the larger one; the second set are white and equal, the preceding being rather the largest; their distance 1¼ diameter of either. The star appears of the fourth magnitude.

σ, or 48 *Orion,* a star of the fourth magnitude, *a little below the lowest of the three stars in the belt.* This is a double-treble star, or two sets of treble stars, almost similarly situated. The two nearest of the preceding set are equal; the third larger, and pretty unequal when compared with the latter two. With a power of 222, the distance of the two nearest is 2 diameters of either. The two nearest of the following set are very unequal. The largest of the two and the farthest are considerably unequal, the largest being white and the smallest bluish. With a power of 222, their distance is about 2½ diameters of the largest. The distance of the two farthest is 43″. Right ascension 5^h 30′; south declination 2° 43′.

θ, *or* 41 *Orion, the small telescopic trapezium in the nebula.* Right ascension 5_h 26′; south declination 5° 32′. The stars composing this quadruple star are considerably unequal. The most southern star of the following side of the trapezium is the largest: the star in the opposite corner is the smallest, the other two being nearly equal. The largest is pale red; the star preceding the largest inclined to garnet; and the star opposite to the largest, dusky. Distance of the two stars in the preceding side, 8¾ seconds; in the southern side, 12¾ seconds; in the following side, 15 seconds; and in the northern side, 20 seconds. The first star (in right ascension) is of the seventh magnitude, the second of the eighth magnitude, the third of the fifth magnitude, and the fourth of the sixth or seventh magnitude. M. Struve found the angles of position in 1819 to be as follow:

3d and 4th:	1st and 3d:
29° 45′ north following.	45° 9′ north preceding.

1st and 2d:	2d and 4th:	2d and 3d:
58° 8′ north fol.	31° 0′ north pre.	74° 0′ north pre.

44 *Orion, preceding the two ι's, or below* 1, 2, θ; *of the third or fourth magnitude.* The preceding set of this double-triple star consists of three equal stars, forming a triangle, and are all dusky. The distance of the two nearest, with a power of 227, is about 3 diameters. The following set consists of three stars of different sizes, forming a circle. The middle star is the largest; the one to the south is pretty large; and the third is very small. The two largest are white, and the smallest pale red. Distance, 36½″. These stars are east by north from the bright star *Rigel*, at the distance of about 5°.

12 *Lynx, below the eye; about* 18° *or* 19° *northeast of Capella, and* 16° *north of β Auriga.* The two nearest of this curious treble star are pretty unequal. The larger is white, and the smaller white inclining to a rose colour. With a power of 227, their distance is ⅓ the diameter of the smaller one. The first and third are considerably unequal; the second and third pretty unequal; the colour of the third being pale red, and its distance from the first 9″.

ξ, or 51 *Libra; of the fourth or fifth magnitude.* This star appears at first double, but the larger of the two will be found to consist of two stars. They are nearly unequal, and both white. With a power of 460, their distance is ¼th the diameter of the larger.

¾° south of 58 *Auriga, in a line parallel to β and θ, southeast of the bright star Capella.* This a cluster of stars, containing a double star of the second class and one of the third. The two of the second are very unequal, and both red. Their distance with 460 is 2½ diameters of the larger. Those of the third class are equal, and both red. Distance, 17″. Above 20 stars are in view with a power of 227.

A large star 1° *preceding ζ towards* 41 *of the Swan.* The two nearest are extremely unequal. The largest is white, and the smallest pale red. Their distance with 460 is 2½ diameters of the largest. The third and the largest are extremely unequal, and belong to the fifth or sixth class.

South preceding 27 *Swan, the middle of three, the most southern of which is the* 27. This star is quadruple and sextuple. In the quadruple of north preceding set, the two nearest are very unequal. Their distance with 278 is 11″. The

two largest are almost equal, and both red. Distance, 29¼″. In the sextuple or south following set, the two largest are pretty unequal, and both red. Their distance is 19″. The other stars are as small as the smallest of the quadruple set.

½° *north preceding* H *Gemini* (of the fifth magnitude), *in a line parallel to the* 65 *Orion* (in the club, and of the fifth magnitude), *and ζ Taurus, the middle of the three.* The stars in this quintuple star are in the form of a cross. The two nearest, or the preceding of the five, are extremely unequal. Distance, 20½″. There is a very obscure star of the third class near the last of the three, in the obscure star of the cross. Other five stars are dispersed about the quintuple one.

Between β and ζ Dolphin, but nearer to β. All the three stars are whitish red, and nearly equal. Distance of the two nearest, with a power of 278, 21½″.

Near 27 Cepheus, near δ. The distance of the two nearest of this treble star is about 20″.

β, or 10 *Lyra* (of the third magnitude, and about 7° southeast of the bright star Vega). The stars of this quadruple star are all white, the second, third, and fourth inclining to red. The first and second are considerably unequal; the first and third very unequal; and the first and fourth unequal. Distance of the first and second, 44″.

β, or 78 *Gemini* (Pollux). The stars of this multiple star are extremely unequal. The nearest distance is 1′ 57″; the next distance is 3′ 17″.

In the Unicorn's head. This multiple star consists of one star with about twelve around it. 16° west of Procyon.

ζ, or 16 *Cancer.* This very minute treble star requires very favourable circumstances to be distinctly seen. The two stars of which the preceding one consists are considerably unequal. The largest of these is larger than the single star, and the least of the two is less than the single star. The first and second largest are pretty unequal, and the second and third pretty unequal. The two nearest are pale red. They are just separated with a power of 278, and with 460 their distance is ¼th the diameter of the smaller one. *Zeta* Cancri is situated about 12 or 13 degrees southeast of Pollux, nearly in a line parallel to that which joins Castor and Pollux, and nearly the same distance north by east from Procyon. It appears as a star of the fifth or sixth magnitude, and is sometimes distinguished by the name *Tegmine.* As a

double star, it is easily distinguished by a power of 140, with a 3½ feet achromatic telescope, whose aperture is 2¾ inches, and might, perhaps, be seen with a power of 100. But it requires a much higher power to distinguish it as a treble star.

Most of the above stars may be found by consulting large planispheres of the heavens, or a common celestial globe. To facilitate the finding out of their positions, I have inserted in the above list some special directions, which may, perhaps, be of use to the astronomical tyro who is furnished with a moderately good telescope. It is to be regretted that, even on some of our latest 18-inch celestial globes, several of the stars above referred to are not distinctly marked, either with their number or with the Greek letters by which they are generally distinguished, and some of them are altogether omitted; such, for instance, as the celebrated star 61 *Cygni*, which is a double star, and whose proper motion is greater than that of any other star yet discovered in the heavens.

CHAPTER X.

ON THE MILKY WAY.

As we advance in our survey of the distant regions of the universe, the astonishing grandeur and extent of the sidereal heavens gradually opens to our view. We have hitherto considered only a few objects on the outskirts of the heavens, in respect to their distance, magnitude, and the wonderful complication of systematic motions which prevails among them. Had we no other objects to engage our attention, ages might be spent in contemplating and admiring the economy and magnificence of those starry groups which appear to the unaided eye on the nearer boundary of our firmament. But all that is visible to man's unassisted vision is as nothing when compared with the immensity of august and splendid objects which stretch themselves in boundless perspective towards infinity. The discoveries of modern astronomy have enlarged the sphere of our conceptions far beyond what could have been formerly surmised, and opened to view a universe boundless

V.

.AR STARS.

[To face page 143.

as its Creator, where human imagination is lost and confounded, and in which man appears like a mere microscopic animalculum, and his whole habitation as a particle of vapour when compared to the ocean. In contemplating the visible firmament with the unassisted eye, we behold only the mere portals, as it were, which lead to the interior recesess of the vast Temple of Creation. When we direct our views beyond these outer portals, by means of the most powerful telescopes, we obtain a view of some of its more magnificent porches, and a faint glimpse of those splendid apartments which we shall never be able to explore, but which lead us to form the most august conceptions of the extent and grandeur of what is concealed from our view. In entering this temple "not made with hands," the splendour of its decorations, the amplitude of its scale, and the awfulness of infinitude, forcibly strike the imagination. There is sufficient to awaken into exercise all the powers and feelings of devotion, and to excite us to fall down in humility and adoration before Him whose word spoke into existence this astonishing fabric, and "whose kingdom ruleth over all." These reflections may not appear altogether unappropriate when entering on a description of the *Milky Way*, which contains objects calculated to excite the highest admiration.

When we take a general view of the heavens about the months of August, September, and October, and during the winter months, we cannot fail observing a large, irregular whitish zone stretching across the sky, with a few interruptions, from one end of the firmament to another. This mighty zone, thus stretching itself around us, is sometimes termed the *galaxy*, sometimes the *Via Lactea*, but more frequently, in plain English, the *Milky Way*, from its resemblance to the whiteness of milk. This luminous band is visible to every observer, and is the only real and sensible circle in the heavens. When traced throughout its different directions, it is found to encircle the whole sphere of the heavens, though in some parts of its course it is broader and more brilliant than in others. It forms nearly a *great circle* of the sphere, but it coincides neither with our equator, ecliptic, nor colures, nor with any other artificial circles which we conceive as drawn around the firmament. In all ages, so far as we know, this wonderful zone has retained the same position among the con-

stellations as at the present day, and is frequently alluded to both by the astronomers and the poets of antiquity. Thus Ovid, on account of its lustre, represents it as the high road to heaven, or the court of Jupiter:

> "A way there is in heaven's extended plain,
> Which, when the skies are clear, is seen below,
> And mortals by the name of *Milky* know;
> The groundwork is of stars, through which the road
> Lies open to the Thunderer's abode."

And Milton, in his "Paradise Lost," alludes to it in these lines:

> "A broad and ample road. whose dust is gold,
> And pavement stars, as stars to us appear;
> Seen in the galaxy that Milky Way,
> Like to a circling zone powdered with stars."

This zone may be traced in the heavens as follows: Beginning near the northern quarter of the heavens, at the head of Cepheus, or about 30° from the north pole, we may trace it through Cassiopeia, Perseus, Auriga, part of Orion, and the feet of Gemini. At this last point it crosses the Zodiac, and, proceeding southward across the equinoctial into the southern hemisphere, it passes through the Unicorn and the middle of the ship, Argo where it is most luminous. It then passes through Charles's Oak, the feet of the Centaur, the Cross, the Altar, the tail of Scorpio, the bow of Sagittarius, and a part of Ophiuchus. Here it separates into two branches as it passes again over the Zodiac into the northern hemisphere. One branch runs through the tail of Scorpio, the bow of Sagittarius, the shield of Sobieski, the feet of Antinous, Aquila, Delphinus, the Arrow, and the Swan. The other branch passes through the upper part of the tail of Scorpio, the side of Serpentarius, Taurus Poniatowski, the Goose, and the neck of the Swan, where it again unites with the other branch, and passes on to the head of Cepheus, the place of its beginning. After sending off the two branches above mentioned, they unite again after remaining separate for the space of more than 100 degrees. There is another small separation of the Milky Stream between Cassiopeia and Perseus. The two streams appear to leave a blank about the head of Perseus, and a considerable space on each side of it, to the extent of about thirty degrees in length and three in breadth, and are

again joined into one stream in the sword of Perseus, adjacent to Cassiopeia.*

From the above description it will appear that the form, breadth, and general appearance of this zone are various in different parts of its circuit round the heavens. In some places it appears dense and luminous, in others faint and scattered; in certain points it appears broad, and in others narrow. Its breadth in some places, as between Auriga and Perseus, is only about four or five degrees; in other places, as in the southern parts of Scorpio, Ara, and the Cross, its breadth is from ten to fifteen or eighteen degrees. It assumes the appearance of a double path from the tail of the Scorpion, through the bow of Sagittarius, Antinous, Aquila, Taurus Poniatowski, the Goose, and part of the Swan. It is more or less visible at every season of the year; but in Britain and in other northern latitudes it is most conspicuous during the months of August, September, and October, the latter part of July, and the beginning of November. About the middle of August, at nine o'clock in the evening, it may be seen stretching in an oblique direction over the heavens, from northeast to southwest, and its apparent motion along the heavens may be traced along with that of the other constellations. At other seasons of the year, and at other hours of the night, its position and form will appear somewhat different. It appears most brilliant in the southern hemisphere, particularly in the neighbourhood of Argo, Ara, and the splendid constellation of the Cross. Between the tropics, where the atmosphere is clear and serene, it appears most vivid and brilliant. Mr. Brydon informs us that, from the top of Etna, it appeared "like a pure flame that shot across the heavens."

The ancients seem to have conjectured that the whiteness of this zone was owing to a confluence of stars; for Ovid, in the lines above quoted, says, "Its groundwork is of stars." Soon after the invention of the telescope, this conjecture was confirmed, and astronomers were astonisheda t the number of stars which appeared in this bright zone of the heavens; and their number appeared to be increased in proportion to the magnifying powers of their telescopes. But it was not before Sir W. Herschel applied his powerful instrument to this

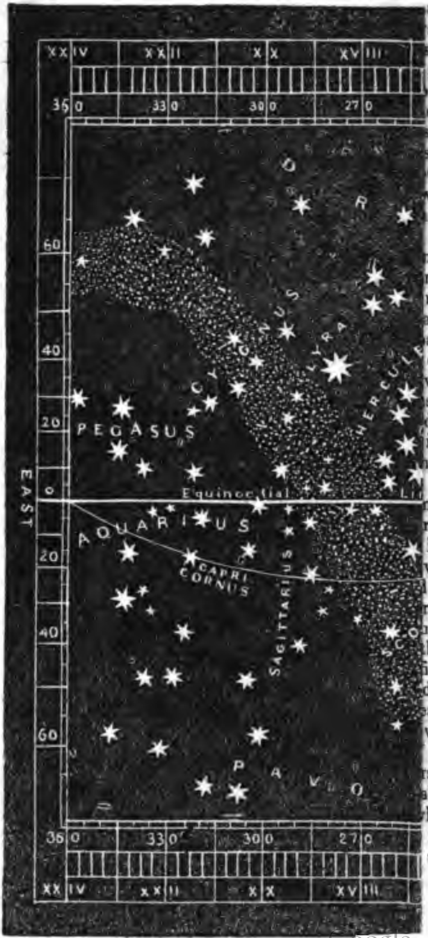
* See the direction of this zone in the map of the stars on Mercator's projection.

region of the heavens that its profundities were explored, and all its minute nebulous parts shown to consist of countless myriads of stars, of every apparent magnitude, stretching onward to the regions of infinity, till they appeared to be lost to the view, even when assisted by the largest telescopes. On first presenting telescopes of considerable power to this splendid zone, we are lost in amazement at the number, the variety, and the beautiful configurations of the stars of which it is composed. In certain parts of it, every slight motion of the telescope presents new groups and new configurations, and the new and wondrous scene is continued over a space of many degrees in succession. In several fields of view, occupying a space not much more than twice the breadth of the moon, you perceive more of these twinkling luminaries than all the stars visible to the naked eye throughout the whole canopy of heaven. You seem to penetrate, as it were, to the remoter boundaries of creation, and feel bewildered and lost amid the immensity of the universe. I have never been inspired with higher ideas of grandeur and sublimity, nor felt deeper emotions of humility and reverence, than when occasionally contemplating this stupendous scene through telescopes of considerable brilliancy and power. There is not another scene in creation, open to the view of mortals, calculated to fill the soul with more august conceptions, or to inspire it with more profound admiration and awe. In such surveys we behold "new heavens" and other firmaments rising to view, whose distances baffle the utmost stretch of imagination.

> "Oh what a confluence of ethereal fires
> From suns unnumber'd down the steep of heaven
> Streams to a point and centres on my sight."

The following contains a brief summary of Sir W. Herschel's observations on this region of the heavens, made with a Newtonian reflecting telescope of twenty feet focal length and an aperture of eighteen inches. He found that this instrument completely resolved all the whitish appearances into stars, which the telescopes he formerly used had not light enough to do. The portion he first observed was that about the hand and club of Orion, and he found in this space an astonishing number of stars, whose number he endeavoured to estimate by counting many *fields*; that is, the apparent space in the heavens he could see at once through his telescope, and

MINIATURE MAP OF THE HEAVENS,



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computing from a mean of these how many may be contained in a given portion of the Milky Way. In the most vacant place to be met with in that neighbourhood he found 63 stars; other six fields contained 110, 60, 70, 90, 70, and 74 stars, a mean of all which gave 79 for the number of stars to each field; and then he found that, by allowing fifteen minutes for the diameter of his field of view, a belt of fifteen degrees long and two broad, which he had often seen pass through his telescope in an hour's time, could not contain less than 50,000 stars, large enough to be distinctly numbered; besides which, he suspected twice as many more, which could be seen only now and then, by faint glimpses, for want of sufficient light. The reader may acquire some conceptions of this immense number of stars occupying so small a space, if he consider that it is fifty times more than all the stars which the naked eye can discern at one time throughout the whole heavens, and that the space they occupy is only the 1-1375th part of the visible canopy of the heavens; so that, if every part of the firmament were equally rich in stars, there would be within the reach of such a telescope as Herschel's no less than 68,750,000, or sixty-eight millions, seven hundred and fifty thousand stars. And we are farther to consider that it was only in the comparatively "vacant places" of this zone that the number of stars above stated were perceived.

In some of his observations on other parts of this zone, Sir W. Herschel informs us that he descried a much greater number of these luminaries in a similar extent of space. "In the most crowded parts of the Milky Way," he says, "I have had fields of view that contained no fewer than 588 stars, and these were continued for many minutes, so that in one quarter of an hour's time there passed no less than 116,000 stars through the field of view of my telescope." In order to appreciate this description, we are to suppose the telescope to have been fixed in one position at the time of observation, and that by the diurnal motion of the earth, or the apparent motion of the heavens, the first field of stars was gradually carried out of view, and other fields appeared in succession, till, in the space of fifteen minutes of time, one hundred and sixteen thousand stars passed over the field of vision. Now the field of view taken in by the telescope was only 15′ of a degree, a space which is less than the *one fourth* part of the apparent size of the moon. In this narrow field were seen about as many stars as are

generally beheld throughout the whole sky by the naked eye in a clear winter's night; for although nearly a thousand stars might be seen by a very acute eye in a clear atmosphere, yet there are few persons that in our climate could distinctly recognise above 600 or 700 stars even in a clear night. At another time, this indefatigable astronomer perceived no less than two hundred and fifty-eight thousand stars pass before his view in the course of forty-one minutes. In the space between β and γ of the Swan, the stars are found clustering, with a kind of division between them, so that they may be considered as clustering towards two different regions. In this space, taking an average breadth of about five degrees of it, he found from observation that it contains more than 331,000 stars, which gives above one hundred and sixty-five thousand for each clustering collection.

Supposing the Milky Way to be, on an average, twelve degrees broad, the whole of it will contain an area of 4320 degrees $= 12 \times 360$. Now if the space examined by Herschel between *Beta* and *Gamma* of the Swan be about fourteen degrees in length and five degrees in breadth, it will contain an area of seventy degrees, which is somewhat less than the 1-61st part of the space occupied by the Milky Way. Were we to suppose every part of this zone equally rich in stars as the space now referred to, it will contain no less than 20,191,000 stars, or more than twenty thousand times the number of those which are visible to the naked eye. The whole visible heavens, considered as a spherical plane, contains an area of 41,253 degrees. Now, could we suppose every portion of the firmament to be equally well replenished with stars as the milky zone, there would be more than 195,000,000* of stars in the heavens discernible by such a telescope as Herschel's; but as there are comparatively few other regions of the heavens so densely crowded with stars as the Milky Way, we must make a certain abatement from this estimate, though it is probable there are more than one hundred millions of stars within the reach of our best instruments, were all the spaces of our firmament thoroughly explored; and future generations, with more powerful telescopes, may add indefinitely to the number. Had we taken the most crowded field of stars which Herschel perceived through his telescope (name-

* 41253-70 = 589 23-70 $\times$ 331,000 = 195,067,757

ly, 588) as our standard for estimating their number, the amount of stars in the Milky Way would have been forty millions, and in the whole heavens 388 millions. In short, to use the words of Sir John Herschel, "This remarkable belt, when examined through powerful telescopes, is found (wonderful to relate !) *to consist entirely of stars scattered by millions*, like glittering dust, on the black ground of the general heavens."

In regard to the *distances* of some of these stars, we may easily conceive that they are immense, and, consequently, far removed from our distinct comprehension. Sir W. Herschel, in endeavouring to determine a "*sounding line*," as he calls it, to fathom the depth of the stratum of stars in the Milky Way, endeavours to prove, by pretty conclusive reasoning, that his twenty feet telescope penetrated to a distance in the profundity of space not less than 497 times the distance of Sirius; so that a stratum of stars amounting to 497 in thickness, each of them as far distant beyond another as the star Sirius is distant from our sun, was within the reach of his vision when looking through that telescope. Now the least distance at which we can conceive Sirius to be from the earth or the sun is 20,000,000,000,000, or twenty billions of miles; and, consequently, the most distant stars visible in his telescope must be four hundred and ninety-seven times this distance, that is, 9,940,000,000,000,000, or nearly ten thousand *billions* of miles! Of such immense distances it is evident we can form nothing approaching to a distinct conception. We can only approximate to a rude and imperfect idea by estimating the time in which the swiftest bodies in nature would move over such vast spaces. Light, which is endowed with the swiftest degree of motion yet known, and which flies at the rate of nearly twelve millions of miles every minute, would require one thousand six hundred and forty years before it could traverse the mighty interval stated above; and a cannon ball, flying at the rate of 500 miles an hour, would occupy more than 2,267,856,068, or two thousand, two hundred and sixty-seven millions, eight hundred thousand years, in passing through the same space! a period of years before which all the duration that has passed since man was placed on this globe appears only like a few fleeting hours, or "as an handbreadth or a span."*

* The celebrated Schroeter, of Lilienthal, was a frequent observer of the stars which crowd the Milky Way. He was in the habit of observing

Here, then, let us pause for a moment, and consider the august spectacle presented to view. We behold a few whitish spaces in the firmament, almost overlooked by a common observer when he casts a rude glance upon the evening sky; yet in this apparently irregular belt, which appears only like an accidental tinge on the face of the firmament, we discover, by optical instruments, what appears to be an amazing and boundless universe. We behold not only ten thousands, but *millions* of splendid suns, where not a single orb can be perceived by the unassisted eye. The distance at which these luminous globes are placed from our abode is altogether overwhelming; even the most lively imagination drops its wing when attempting its flight into such unfathomable regions. The scenes of grandeur and magnificence connected with such august objects are utterly overwhelming to such frail and limited beings as man, and perhaps even more exalted orders of intelligences may find it difficult to form even an approximate idea of objects so distant, so numerous, and so sublime.

On our first excursions into the celestial regions we are almost frightened at the idea of the distance of such a body as Saturn, which a cannon ball projected from the earth, and flying with its utmost velocity, would not reach in 180 years. We are astonished at the size of such a planet as Jupiter, which could contain within its circumference more than a

with one of the largest reflecting telescopes to be found in Europe. This telescope was one of the finest ever constructed, and was the workmanship of Professor Schrader, of Kiel. The diameter of the speculum was about nineteen inches; it was about two inches in thickness, and towards the edge cast conical, so that the diameter of the polished surface is almost a quarter of an inch less than at the back, which circumstance was considered of the greatest utility in the finishing and polishing. It had a focus of twenty-six feet, and, without the frame, weighed eighty pounds. The large octangular tube was constructed with boards, made impenetrable to rain; and the instrument, when ready for use, was twenty-seven feet long. An immense quantity of apparatus and machinery was requisite for steadying and moving it. The figure of the speculum was so perfect, that it could bear a power of 800 or 1000 times without diminishing the aperture. Its capability of resolving the nebulosity of the Milky Way seems to have equalled that of the telescopes of Herschel. He allowed twenty degrees of its length from *a* Cygni to pass through the field, and the sight drew from him the natural exclamation, "What omnipotence!" The power on the telescope in such observations was 179, and the diameter of the field fifteen minutes; and the number of stars it contained at once could never be counted. They were never estimated at less than fifty or sixty, and often reached or exceeded 150. He calculated that the number of stars visible through this telescope could not be less than 12,000,000.

thousand globes as large as the earth. We are justly amazed at the stupendous magnitude of the sun, which is a thousand times the size of Jupiter, and which illuminates with its splendour a sphere of more than five thousand millions of miles in circumference. But what are all such distances and dimensions, vast and amazing as they are, compared with the astonishing grandeur of the scene before us? They sink into comparative insignificance, and are almost lost sight of amid the myriads of splendid suns which occupy the profundities of the Milky Way. What is *one* sun and *one* planetary system in the presence of *ten millions* of suns, perhaps far more resplendent, and of a hundred times this number of spacious worlds, which doubtless revolve around them? Yet this scene, stupendous as it is, is not the universe. It is, perhaps, as we shall see, only a comparatively small corner of creation, which beings at an immensely greater distance will behold as an obscure and scarcely discernible speck on the outskirts of their firmament; so that, amid this vast assemblage of material existence, we may say, in the language of the inspired prophet when speaking of the Almighty, that *even here* is but "the hiding of his power." What, then, must the whole of creation be? and what must be the ineffable splendour and majesty of Him who laid the plan of the mighty fabric, whose breath kindled so many millions of suns, whose hands set in motion so many myriads of rolling worlds, who supports them in their ample and diversified courses, and whose moral government extends over all? And what is man, and the globe on which he dwells, amid this scene of immensity and magnificence? an atom in the infinity of space; a particle of vapour compared to the ocean; a being who, in respect to the magnificence of creation and the grandeur of his Creator, is "as nothing, and is counted to him as less than nothing and vanity."

Yet, amid all the magnificence of this vast system of universal nature, man is not forgotten by his Maker; his hand supports him, his wisdom guides him, and his overflowing goodness provides, in a thousand different modes, for his happiness and enjoyment. He shares of the Divine beneficence and care in common with all the bright intelligences that people the amplitudes of creation, and is as amply provided for as if the Almighty had no other world under his superintendence. Within the moral government of the Creator of the universe he may rest secure and confident that he is not over-

looked amid the immensity of being, for his presence pervades the infinity of space, and his knowledge extends to the minutest movements of all his creatures. Under his paternal care, not only man, but the crawling worm, the fluttering insect, the little ant, and even the microscopic animalculum, find a home and provisions, as well as the highest order of his creatures; for "he openeth his hand and supplieth the wants of every living being."

Notwithstanding the size of the Milky Way, and the immense number of stars of which it is composed, it is now considered as nothing more than *one of the nebulæ*, or starry systems, which appear to be dispersed throughout the universe. It is supposed, and with some reason, that it is the nebula, or assemblage of stars, in which our sun is placed. Its situation in this nebula is reckoned to be, not in the centre of its thickness, but rather towards one of its sides, near the point where it diverges into two branches. According to this hypothesis, the Milky Way is to be considered as the projection of the nebula upon the concave surface of the sky, as seen from a point within it. "We gather this," says Sir W. Herschel, "from the appearance of the galaxy, which seems to encompass the whole heavens, as it certainly must do if the sun is within the same; for suppose a number of stars arranged between two parallel planes indefinitely extended every way, but at a given considerable distance from one another, and calling this a sidereal stratum, an eye placed somewhere within it will see all the stars in the direction of the planes of the stratum projected into a great circle, which will appear lucid on account of the accumulation of the stars, while the rest of the heavens at the sides will only seem to be scattered over with constellations, more or less crowded, according to the distance of the planes or number of stars contained in the thickness or sides of the stratum."

Thus, if the solar system be supposed at *S*, in the middle of the nebula *a b c d e f*, with two branches, *a c*, *b c* (fig. 38), the nebula will be projected into a circle *A B C D*, the arches *A B C*, *A E C*, being the projection of the branches *a c*, *b c*, while the stars near the sides of the stratum will be seen scattered over the remaining part of the heavens among the spaces *F*, *I*, *H*, *K*, *G*. If the eye were placed somewhere without the stratum, at no very great distance, the appearance of the stars within it would assume the form of one of

Fig. 38.

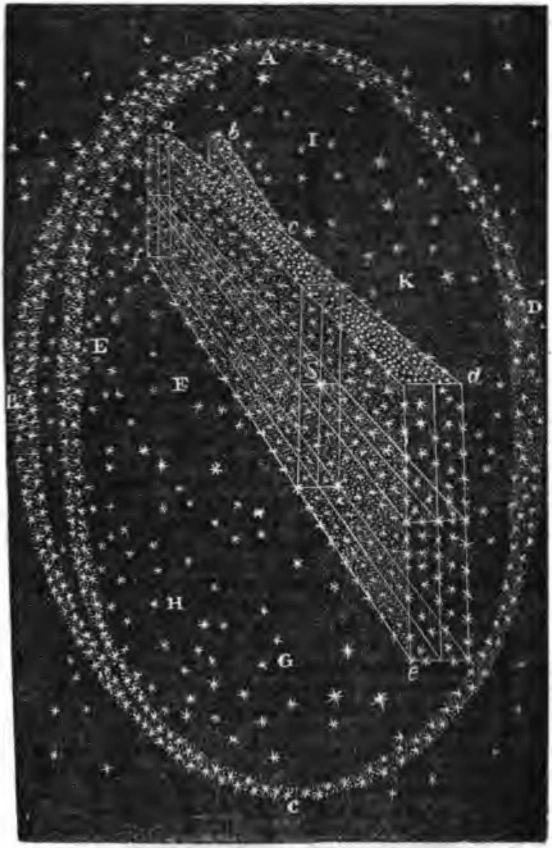
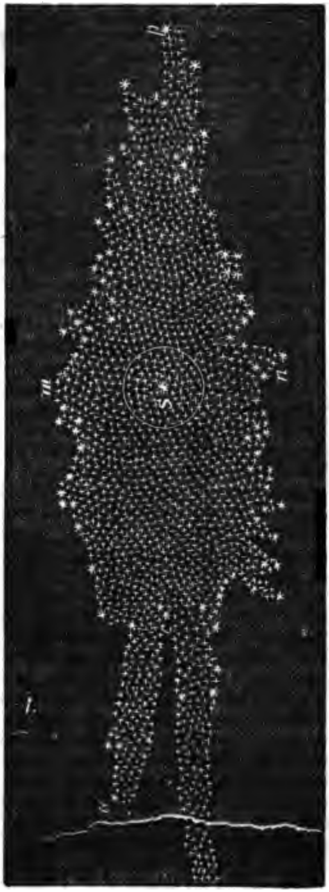


Fig. 39.



the lesser circles of the sphere, which would be more or less contracted according to the distance of the eye; and if this distance were exceedingly increased, the whole stratum might at last be drawn together into a lucid spot of any shape, according to the position, length, and height of the stratum.

In order to determine those points, Sir W. Herschel put in practice a method which he calls *gauging the heavens*, which consists in repeatedly counting the number of stars in the fields of view very near each other, by which he obtained a mean of the number of stars in that part of the heavens. He then proceeds on the supposition that the stars are equally scattered, and, from the number of stars in any part of the heavens, he deduces the length of his visual ray, or the distance through which his telescope had penetrated, or, in other words, the distance of the remotest stars in that particular region of the heavens. To illustrate this, let us suppose the Milky Way a nebula, and that the sun is not placed in its centre. Then, on the supposition that the stars are nearly equally scattered, it is evident that the part of the Milky Way where the stars are most numerous must extend farthest from the sun, and the parts where they are less numerous must extend to a less distance. Proceeding on these grounds, Sir W. Herschel found the length of his visual ray for different parts of the heavens. In some cases he found it equal to 497 times the distance of Sirius, supposed to be the nearest star, as formerly stated. The following is a representation of a section of the nebula of the Milky Way according to his delineation. This section is one which makes an angle of thirty-five degrees with our equator, crossing it in 124½ and 304½ degrees. A celestial globe adjusted to the latitude of fifty-five degrees north, and having σ *Ceti* near the meridian, will have the plane of this section pointed out by the horizon. If the solar system (fig. 39) be at *S*, the brightness of the Milky Way will be greatest in the directions *S a*, *S b*, *S p*, where the stars that intervene are most numerous, or where the visual ray is longest. In the lateral directions *S n*, *S m*, the nebulosity will not appear, from the small number of interposing stars, and the stars, though numerous, will appear more scattered. In the direction *S c*, on account of the opening between *a* and *b*, there will be an empty space contained between these two branches, where the nebulosity is not observed, as is the case in the Milky Zone between μ Scorpio

in the south and γ Cygni in the north, a length of about 102 degrees. The stars in the border, which are marked larger than the rest, are those pointed out by the gauges; the intermediate parts are filled up by smaller stars arranged in straight lines between the gauged ones. The circle described around *S* represents an extent about forty times the distance of the nearest fixed stars, which may be considered as comprehending all those which are visible to the naked eye.

"From this figure," says Sir W. Herschel, "we may see that our nebula is a very extensive, branching, compound congeries of *many millions of stars*, which most probably owes its origin to many remarkably large, as well as pretty closely scattered small stars, that may have drawn together the rest." Again: "If it were possible to distinguish between the parts of an indefinitely extended whole, the nebula we inhabit might be said to be one that has fewer marks of antiquity than any of the rest. To explain this idea more clearly, we should recollect that the condensation of clusters of stars has been ascribed to a gradual approach; and whoever reflects on the number of ages that must have passed before some of the clusters that are to be found in my intended catalogue could be so far condensed as we find them at present, will not wonder if I ascribe a certain air of youth and vigour to very many regularly scattered regions of our sidereal stratum. There are, moreover, many places in it in which, if we may judge from some appearances, there is the greatest reason to believe that the stars are drawing towards secondary centres, and will in time separate into clusters, so as to occasion many subdivisions. Our system, after numbers of ages, may very possibly become divided so as to give rise to a stratum of two or three hundred nebulæ; for it would not be difficult to point out so many beginning or gathering clusters in it. This throws considerable light upon that remarkable collection of many hundreds of nebulæ which are to be seen in what I have called the *nebulous stratum* in Coma Berenices. It appears, from the branching and extended figure of our nebula, that there is room for the decomposed small nebulæ of a large reduced former great one to approach nearer to us in the sides than in any other parts." . . . . "Some parts of our system seem, indeed, already to have sustained greater ravages of time than others; for instance, in the body of the Scorpion is an opening or hole, which is probably owing to

this cause. It is at least four degrees broad, but its height I have not yet ascertained. It is remarkable that the 80th nebula of the *Connoissance des Temps*, which is one of the richest and most compressed clusters of small stars I remember to have seen, is situated just on the west border of it, and would almost authorize a suspicion that the stars of which it is composed were collected from that place, and had left the vacancy."

The remarks in the above paragraph I present to the reader merely as the opinions of an illustrious astronomer and an indefatigable observer of celestial phenomena, without vouching for the accuracy or probability of such speculations and hypotheses. To determine the reality of such changes in bodies so numerous and so distant, would require an indefinite lapse of ages; yea, perhaps the revolutions of eternity are alone sufficient for determining the sublime movements and changes which happen among the immense assemblages of material existence which constitute the universe. There is a high degree of probability that everything within the material system is liable to change of one kind or another, and that there is no sun nor world, among all the myriads of globes which replenish the sidereal heavens, but what is *actually in motion*, and moving, too, with a velocity which the inhabitants of such a world as ours can scarcely appreciate; and such motions, in the course of ages, may be productive of a vast diversity of scenery in different regions of the universe. And if so, it presents to view another instance of that *variety* which the Creator has introduced into his universal kingdom to gratify the unbounded desires of intelligent beings.

I shall conclude this chapter with the following description of the Milky Way, which Sir John Herschel has published since his residence in the southern hemisphere: "The general aspect of the southern circumpolar region—including in that expression sixty or seventy degrees of south-polar distance—is in a high degree rich and magnificent, owing to the superior brilliancy and larger development of the Milky Way, which, from the constellation of Orion to that of Antinous, is in a blaze of light, strangely interrupted, however, with almost starless patches, especially in Scorpio, near *α* Centauri and the Cross; while to the north it fades away pale and dim, and is, in comparison, hardly traceable. I think it is impossible to view this splendid zone, with the astonishingly rich and evenly distrib-

uted fringe of stars of the third and fourth magnitudes—which form a broad skirt to its southern border, like a vast curtain—without an impression amounting almost to a conviction that the Milky Way is not a mere stratum, but an *annulus*; or, at least, that our system is placed within one of the poorer or almost vacant parts of its general mass, and that eccentrically, so as to be nearer to the parts about the Cross than to that diametrically opposed to it."

CHAPTER XI.

ON GROUPS AND CLUSTERS OF STARS.

On a cursory view of the heavens, the stars appear to be very irregularly scattered over the concave of the firmament. In some places a considerable interval appears between neighbouring stars, while in others they appear so crowded that the eye can with difficulty perceive the spaces between them. Even to the unassisted eye, there are certain groups of this description which strike the attention of every observer, and lead to the conclusion that the stars of which they are composed have been brought together by some general law, and not by mere casual distribution. Of these, the group called the *Pleiades*, or Seven Stars, is the most obvious to common observers. This group is situated in the constellation Taurus, about 14° to the westward of the star Aldebaran (*see* Plate I.), and may be seen every clear evening from the end of August till the middle of April.* It is generally reckoned that only *six* stars can be distinctly counted in this group by common eyes, but that originally they consisted of *seven*, which every one could easily perceive, and it has therefore been conjectured that one of them has long since disappeared. To this circumstance Ovid, who lived in the time of our Saviour, alludes in these lines:

> "Now rise the *Pleiades*, those nymphs so fair,
> Once seven numbered, now but six there are."†

* A telescopic view of the Pleiades is exhibited in the Appendix.
† "Quæ septem dici, sex tamen esse solent."

In fabulous history it is said that in the Pleiades the star Merope, one of the Atlantides, appears more dim and obscure than the rest, or is altogether extinguished, because, as the poets fancy, she married a mortal, while her sisters married some of the gods or their descendants. Dr. Long, however, declares that he himself had more than once seen seven stars in this group; and a learned astronomical friend assured him that he had seen eight stars among the Pleiades, where common eyes can discover but six; and Kepler says of his tutor Mæstlinus, that "he could reckon fourteen stars in the Pleiades without any glasses." This difference in the number seen by different persons in this group is obviously owing to the different degrees of acuteness of vision possessed by the respective individuals. However small the number perceived by the naked eye, the telescope shows them to be a pretty numerous assemblage. Dr. Hook, formerly professor of geometry in Gresham College, informs us that, directing his twelve-feet telescope (which could magnify only about seventy times) to the Pleiades, he did in that small compass count seventy-eight stars; and making use of longer and more perfect telescopes, he discovered a great many more of different magnitudes.

The ingenious Mr. Mitchell, more than fifty years ago, started the idea of the stars being formed into groups or systems which are entirely detached from one another, and have no immediate connexion. In reference to the Pleiades, he conducted his reasoning as follows: "The Pleiades are composed of six remarkable stars, which are placed in the midst of a number of others that are all between the third and sixth magnitudes; and comparing this number six with the whole number visible in the heavens to the naked eye, he calculated, by the doctrine of chances, that among all this number, if they had been dispersed arbitrarily through the celestial vault, it was about five hundred millions to one that six of them should be placed together in so small a space. It is therefore so many chances to one that this distribution was the result of design, or that there is a reason or cause for such an assemblage."

The constellation called *Coma Berenices* is another group, more diffused than the Pleiades, which consists chiefly of small stars which can scarcely be distinguished in the presence of the moon. This beautiful cluster lies about five degrees east

of the equinoctial colure, and midway between the star *Cor Caroli* on the northeast, and Denebola, in the Lion's tail, on the southwest. If a straight line be drawn from *Benetnasch*—the star at the extremity of the tail of the Great Bear—through Cor Caroli, and produced to Denebola, it will pass through this cluster. It may also be distinguished as situated about twenty-six degrees west by north from the bright star *Arcturus*. The confused lustre of this assemblage of small stars bears a certain resemblance to that of the Milky Way, and, besides the stars of which it is chiefly composed, it contains a number of nebulæ. Sir W. Herschel supposes that the stratum of nebulæ in this quarter runs out a very considerable way, and that it may even make the circuit of the heavens, though not in one of the great circles of the sphere. He also supposes that the situation of the stratum is nearly at right angles with the great sidereal stratum in which the sun is placed; that the Coma itself is one of the clusters in it; and that it is on account of its nearness that it appears to be so scattered. He apprehends that the direction of it towards the north lies probably, with some windings, through the Great Bear onward to Cassiopeia, thence through the girdle of Andromeda and the Northern Fish, proceeding towards Cetus; while towards the south it passes through the Virgin, probably on to the tail of Hydra and Centaurus.

Another group, somewhat similar, but less definite, is found in the constellation of Cancer; it is called *Præsepe*, or the Bee Hive, and is a nebulous cluster of very minute stars, not separately distinguishable by the naked eye. A telescope of very moderate power, however, easily revolves it into small stars. It is sufficiently luminous to be seen as a nebulous speck by the unassisted eye, and is somewhat like the nucleus of a comet, for which it has frequently been mistaken by ordinary observers. It is situated in a triangular position with regard to Castor and Procyon, or the Little Dog. A line drawn from Procyon in a northeasterly direction meets with Præsepe at the distance of twenty degrees. This line, drawn in a northwesterly direction from Præsepe, meets Castor at the same distance. These lines form nearly a right angle, the angular point being in Præsepe. It may otherwise be discovered by means of two stars of the fourth magnitude lying one on either side of it at the distance of about two degrees. It may likewise be found by conceiving a line drawn through

Castor and Pollux to the southeast, and continued about fifteen degrees, or three times the distance between Castor and Pollux. This cluster, Sir W. Herschel thinks, belongs to a certain nebulous stratum so placed as to lie nearest us. This stratum runs from ε Cancri towards the south, over the 67th nebula of the *Connoissance des Temps*, which is a very beautiful and much compressed cluster of stars, easily to be seen by any good telescope, and in which he has observed about 200 stars at once in the field of view of his great reflector, with a power of 157. This cluster appearing so plainly with any good common telescope, and being so near to the one which may be seen with the naked eye, denotes it to be probably the next in distance to that within the quartile formed by $\gamma\ \delta\ \eta\ \theta$. From the 57th nebula, the stratum of Cancer proceeds towards the head of Hydra.

I have seldom contemplated a more brilliant and beautiful view in the heavens than one of the fields of view of this cluster of stars. With a 3½ feet achromatic, and a power of 95, I have counted from fifty to seventy stars. Fifteen or twenty of the most brilliant of these presented beautiful configurations: one of them was an equilateral triangle; another an isoscelus; a third nearly of the figure of a cone; a fourth parallel lines, &c. In more than two instances, three brilliant equidistant stars appeared in a straight line, similar to the belt of Orion, while a considerable number of the remaining stars appeared extremely small. With a 6½ feet achromatic, whose object-glass is 4 inches diameter, and a power of 110, this view was rendered still more brilliant. Several fields of view, nearly of this description, may be perceived in the cluster. Fig. 40 represents one of these views, in which some of the smaller stars are omitted. This view was taken with the 3½ feet telescope, having an erect eyepiece. The configurations appear somewhat different in their relations to each other when viewed with an inverting eyepiece.

Another cluster is found in the sword-handle of *Perseus*, which is crowded with stars of a smaller size than in the clusters already noticed, and which requires a telescope of greater power to resolve them and show them separated from each other. Perseus is one of the northern circumpolar constellations, nearly opposite to the three stars in the tail of the Great Bear. A line drawn from these stars through the Pole-star meets the sword and head of Perseus at nearly an equal

Fig. 40.

distance on the opposite side. It is directly north of the Pleiades, between Andromeda and Auriga. The sword is in the neighbourhood of Cassiopeia. A line drawn from *Algenib*, the brightest star in this constellation, to the middle of Cassiopeia, passes through the sword-handle where the cluster is situated, which is about midway between these two objects.

If the lowermost of the three small stars which form the *sword* of Orion be viewed with a good telescope, a beautiful configuration of stars will be perceived. Fig. 41* represents the principal stars comprehended in one field of view at this point, as taken with a six feet and a half telescope, with an inverting eyepiece, magnifying 110 times; it exhibits a distant resemblance of the whole constellation of Orion as seen

Fig 41.*

by the naked eye. But in the neighbourhood of certain parts of the Milky Way, particularly about the regions in the vicinity of the star *Altair* and in the constellation Cassiopeia, the stars, though smaller, are much more numerous. With a very moderate power on the above-mentioned telescope, I have had fields of view of from fifty to a hundred stars, some of them beautifully arranged, and such fields continued over a space of several degrees.

The above may be considered as specimens of groups of stars, which every one possessed of telescopes may easily examine for himself. They form very beautiful objects for exhibiting to young people and to amateurs in astronomy; and it cannot but strike the mind with wonder and admiration to

behold, in one point of view, within a space little more than that of the *one fifth* of the apparent size of the moon, nearly a hundred resplendent suns emitting their effulgence from regions immeasurably distant, and arranged in beautiful symmetry and order; a scene of creating power surpassing in grandeur ten thousand worlds such as ours, and in which our whole planetary system would appear only as the smallest twinkling star. Such telescopic views of the nocturnal heavens have a tendency to expand the capacity of the soul, to inspire it with magnificent conceptions, and to raise its affections above the low ambition and paltry concerns of this transitory scene to the distant and more magnificent scenes of the Divine empire. To the devout and contemplative philosopher the following lines of the poet may be applied:

> "Not to this evanescent speck of earth
> Poorly confined—the radiant tracks on high
> Are his exalted range; intent to gaze
> Creation through, and from that full complex
> Of never-ending wonders to conceive
> Of the sole Being right, who spoke the word,
> And nature moved complete."—THOMSON'S SUMMER.

Sir W. Herschel makes a distinction between *groups* and *clusters* of stars. A group is a collection of stars closely and almost equally compressed, and of any figure or outline. There is no particular condensation of the stars to indicate the existence of a central force, and the groups are sufficiently separated from neighbouring stars to show that they form peculiar systems of their own. According to this definition, the congeries of stars I have pointed out above are to be considered as belonging to the class of *groups*. *Clusters* of stars differ from groups in their beautiful and artificial arrangement. Their form is generally round, and their condensation is such as to produce a mottled lustre somewhat resembling a nucleus. The whole appearance of a cluster indicates the existence of a central force, residing either in a central body or in the centre of gravity of the whole system. The stars of which it is composed appear more and more accumulated towards the centre.

Many such clusters are found in the heavens invisible to the naked eye, and whose existence as dim specks of light can only be recognised by the assistance of optical instruments. Telescopes of moderate power exhibit them only as small round or oval specks, somewhat resembling comets without

tails; but when these objects are examined with telescopes of great power, "they are then," as Sir J. Herschel remarks, "for the most part, perceived to consist entirely of stars crowded together so as to occupy almost a definite outline, and to run up to a blaze of light in the centre, where their condensation is usually the greatest." "Many of them, indeed, are of an exactly round figure, and convey the complete idea of a globular space filled full of stars, insulated in the heavens, and constituting in itself a family or society apart from the rest, and subject to its own internal laws. It would be a vain task to attempt to count the stars in one of these *globular clusters*. They are not to be reckoned by hundreds; and on a rough calculation, grounded on the apparent intervals between them at the borders (where they are seen not projected on each other) and the angular diameter of the whole group, it would appear that many clusters of this description must contain at least ten or twenty thousand stars, compacted and wedged together in a round space, whose angular diameter does not exceed eight or ten minutes; that is to say, in an area not more than a tenth part of that covered by the moon." The stars composing such clusters appear to form a system of a peculiar and definite character. "Their round figure clearly indicates the existence of some general bond of union in the nature of an attractive force, and in many of them there is an evident acceleration in the rate of condensation as we approach the centre, which is not referable to a merely uniform distribution of equidistant stars through a globular space, but marks an intrinsic *density* in their state of aggregation, greater at the centre than at the surface of the mass."

Let the reader pause for a moment on the object now described, and consider the glimpse it affords us of the immensity of the universe, and of the innumerable globes of light with which it is replenished. A point in the firmament, scarcely perceptible to the unassisted eye, which a common telescope shows only as a small, dim, round speck, yet is found by powerful instruments to consist entirely of stars to the number of *ten or twenty thousand!* At what a distance must such a cluster be when its stars appear to be blended and projected one upon another, hundreds of them appearing only like a lucid point! and yet the distance between any two of them is perhaps ten thousand times greater than that of Saturn from our globe. From such a region even light itself must take

many thousands of years ere it can reach our world. In this almost invisible point, which not one out of fifty thousand, or even one out of a million of earth's inhabitants has yet perceived, what a scene of grandeur and beneficence may be displayed; and what a confluence of suns, and systems, and worlds, and intelligences of various orders, may exist, displaying the power, and wisdom, and goodness of the great Father of all! Every circumstance connected with such an object shows that its distance must be immeasurably great, and, consequently, the luminaries of which it is composed immense in magnitude. But suns of such size and splendour cannot be supposed to be thrown together at random through the regions of infinity, without any ultimate design worthy of the Creator, or without relation to the enjoyments of intelligent existence; and therefore we may reasonably conclude, that ten thousand times ten thousands, and myriads of myriads of exalted intelligences exist in that far-distant region, compared with the number of which all the inhabitants of our globe are but "as the drop of a bucket, or as the small dust of the balance."

In short, in this dim and almost imperceptible speck we have concentrated a confluence of suns and worlds, at least ten times surpassing in size and splendour the sun, moon, and planets, and all the stars visible to the naked eye throughout all the spaces of our firmament! What, then, must be the number and magnitude of all the other clusters which the telescope has brought to view? what the number of those which lie beyond the limits of human vision in the unexplored regions of immensity? and what must the UNIVERSE itself be, of which all those numerous starry systems are but an inconsiderable part? Here the human faculties are completely lost amid the immensity of matter, magnitude, motion, and intelligent existence, and we can only exclaim, "Great and marvellous are thy works, Lord God Almighty!"

Figure 41 represents a view of one of the clusters alluded to above, as seen in the twenty-feet reflector at Slough. Sir J. Herschel, who has given a delineation of it in his "Treatise on Astronomy," says, "it represents, somewhat rudely, the thirteenth nebula of Messier's list, described by him as *nebuleuse sans etoiles*." Its right ascension is $16^{h}\,36'$, and its north declination $36^{\circ}\,46'$; by which its place may easily be found on a celestial globe. It is situated in the constellation Hercules, between the stars η and ζ. These stars are of the third

magnitude, and lie north and south of each other, at the distance of seven degrees and a third; they come to the meridian about the middle of July, at nine o'clock in the evening, but of course may be seen at many other periods of the year, particularly in the spring and autumn. The star η lies about twenty-two degrees nearly due west from the bright star *Vega* or α Lyræ. In the map of the stars on Plate II. it is marked with the letter *a*, and the star ζ below it with the letter *b*. The cluster is somewhat nearer to η, or the upper star, than to the other. It is just perceptible to the naked eye, and with a telescope of small power, such as a common "night and day telescope," it appears like a small round comet.

The following is a list of the places of six of the principal clusters of this description, which may be considered as specimens of these remarkable objects:

1. Right ascension, 15^h $10'$; north declination, $2°$ $44'$. This cluster lies about eight degrees southwest from *Unuk*, the principal star in the Serpent, and comes to the meridian about the middle of June, at nine o'clock in the evening.

2. Right ascension, 13^h $34'$; north declination, $29°$ $15'$; between the tail of Chara and the thigh of Bootes, about twelve degrees northwest of Arcturus, nearly on a line between that star and *Cor Caroli*, but nearer Arcturus.

3. Right ascension, 13^h $5'$; north declination, $19°$ $5'$; in Coma Berenices, fourteen degrees west by south of Arcturus. A line drawn from Arcturus through η Bootes meets this cluster at somewhat more than double the distance of these two stars.

4. Right ascension, 17^h $29'$; south declination, $3°$ $8'$; between the stars γ and μ of Serpentarius, but nearer to the latter.

5. Right ascension, 21^h $25'$; south declination, $1°$ $34'$; in Aquarius, about five degrees north of η in the west shoulder, nearly in a line with ϵ *Pegasi*, or *Enif*.

6. Right ascension, 21^h $22'$; north declination, $11°$ $26'$. This cluster lies north from No. 5, at the distance of thirteen degrees, and about three or four degrees northwest of the star *Enif*, or ϵ Pegasi.

Such are a few specimens of *compressed* clusters of stars. Sir W. Herschel has given a catalogue of more than a hundred of such clusters dispersed over different parts of the heavens, many of which require powerful telescopes to resolve

P

them into stars. These clusters may be considered as so many distinct *firmaments*, distributed throughout the spaces of immensity, each of them comprising within itself an assemblage of stars far more numerous than what appears to the vulgar eye throughout the whole face of our nocturnal sky. To those intelligences that reside near the centre of such clusters, the stars connected with their own cluster or system will be those which they will chiefly behold in their sky; and in those clusters which are of a globular form, the stars will appear nearly equally dispersed over the face of their firmament. In these starry assemblages which show a great compression about the centre, an immense number of stars of the first magnitude will decorate their sky, and render it far more resplendent than that with which we are surrounded; another instance of that *variety* which distinguishes all the scenes of creation. Scarcely any other stars will be visible except those which belong to their own system. If the magnificent system of stars with which our sun is connected be at all visible, it will only appear like a dim and inconsiderable speck in the remote regions of immensity, or as a small cluster or nebula, such as those we perceive with difficulty through our telescopes. Such are the grand, the diversified, and wonderful plans of the Creator throughout his vast and boundless universe.

CHAPTER XII.

ON THE DIFFERENT ORDERS OF THE NEBULÆ.

Section I.—*General Remarks on the Subject of Nebulæ.*

The farther we proceed in our researches into the sidereal heavens, the scene of Creating Power and Wisdom becomes more expansive and magnificent. At every step of our progress the prospect enlarges far beyond what we had previously conceived; the multitude and variety of its objects are indefinitely increased; new suns and new firmaments open to view on every hand, overwhelming the mind with astonishment and wonder at the immensity of Creation, and leaving it no room

to doubt that, after all its excursions, it has arrived only at "the frontiers of the Great Jehovah's kingdom." Wherever we turn our eyes amid those higher regions, infinity appears to stretch before us on either hand, and countless assemblages of the most resplendent objects are everywhere found diversifying the tracts of immensity. To investigate such objects in relation to their number, magnitude, motion, and the laws by which they are united and directed in their movements, completely baffles the mathematician's skill, and sets all his hitherto acquired powers of analysis at defiance, and demonstrates that we are still in the infancy of knowledge and of being. Here all finite measures fail us in attempting to scan such amazing objects, and to penetrate into such unfathomable recesses; length, breadth, depth, and height, and time and space, are lost. We are justly filled with admiration at the amazing grandeur of the Milky Way, where suns and worlds are counted by MILLIONS. When exploring its dimensions and sounding its profundities, we seem to have got a view of a universe far more expansive than what we had previously conceived to be the extent of the whole creation. But what shall we say if this vast assemblage of starry systems be found to be no more than a *single nebula*, of which several thousands, perhaps even richer in stars, have already been discovered! and that it bears no more proportion to the whole of the sidereal heavens around us than a small dusky speck which our telescopes enable us to descry! Yet such is the conclusion which we are led to deduce from the discoveries which have been lately made respecting the different orders of the nebulæ, of which I shall now proceed to give a brief description.

The word *nebula* literally signifies a *cloud* or mist. This name is now used in astronomy to denote certain small spots, resembling whitish clouds, which are seen in the starry heavens by the telescope, and which present different kinds of appearances, either that of single stars enveloped in a nebulous veil, or of groups of small stars, or only the appearance of a shining or glittering cloud, which last are the nebulæ properly so called. The following are some general observations on the nebulæ by Sir William Herschel. The success which accompanied the observations of this eminent astronomer in reference to the Milky Way, induced him to turn his telescope to the nebulous parts of the heavens, of which an accurate list had been published in the *Connoissance des*

*Temps** for 1783 and 1784. Most of these yielded to a Newtonian reflector of 20 feet focal distance and 12 inches aperture, which plainly discovered them to be composed of stars, or at least to contain stars, and to show every other indication of their consisting of them entirely.

"The nebulæ," says he, "are arranged into strata, and run on to a great length; and some of them I have been able to pursue, and to guess pretty well at their form and direction. It is probable enough that they may surround the whole starry sphere of the heavens, not unlike the Milky Way, which undoubtedly is nothing but a stratum of fixed stars. And as this latter immense starry bed is not of equal breadth or lustre in every part, nor runs on in one straight direction, but is curved and even divided into streams along a very considerable portion of it, we may likewise expect the greatest variety in the strata of the clusters of stars and nebula. One of these nebulous beds is so rich, that, in passing through a section of it, in the time of only thirty-six minutes, I have detected no less than thirty-one nebulæ all distinctly visible upon a fine blue sky. Their situation and shape, as well as condition, seem to denote the greatest variety imaginable. In another stratum, or perhaps a different branch of the former, I have seen double and treble nebulæ variously arranged; large ones with small, seeming attendants; narrow, but much extended lucid nebulæ or bright dashes; some of the shape of a fan, resembling an electric brush issuing from a lucid point; others of the cometic shape, with a seeming nucleus in the centre, or like cloudy stars surrounded with a nebulous atmosphere. A different sort, again, contain a nebulosity of the milky kind, like that wonderful, inexplicable phenomenon about θ Orionis; while others shine with a fainter mottled kind of light, which denotes their being resolvable into stars."

"In my late observations on nebulæ," says Sir William, on another occasion, "I have found that I generally detected them in certain directions rather than in others; that the

* *Connoissance des Temps*, or, as it is sometimes written, *Connaissance des Tems*, literally signifies *the knowledge of time*. It is the title of an almanac, or astronomical ephemeris, published at Paris, on nearly the same plan as the "Nautical Almanac," published at London. The following is the title of one published in the year 1825: "Connaissance des Tems, ou, des Mouvemens Celestes, à l'Usage des Astronomes et des Navigateurs, pour l'an 1828. Publiée par le Bureau des Longitudes." It contains 216 pages.

spaces preceding them were generally quite deprived of their stars, so as often to afford many fields without a single star in it; that the nebulæ generally appeared some time after among stars of a certain considerable size, and but seldom among very small stars; and when I came to one nebulæ, I generally found several more in the neighbourhood; that afterward a considerable time passed before I came to another parcel. These events being often repeated in different altitudes of my instrument, and some of them at considerable distances from each other, it occurred to me that the intermediate spaces between the sweeps might also contain nebulæ; and finding this to hold good more than once, I ventured to give notice to my assistant at the clock that 'I found myself on nebulous ground.'" From these observations of Herschel, it appears that the nebulæ are not dispersed indiscriminately through the heavens, but are found in certain regions and directions rather than in others, and that, as formerly stated, they probably make the circuit of the heavens, intersecting at a certain angle the Milky Way.

More than eighty years ago, it was suggested by the celebrated mathematician and astronomer, M. Lambert, in his "Letters on Cosmogony," that all the stars in the universe are collected into systems; that all these systems are in motion; that the individual stars or suns of each system move round a common centre of gravity, which may possibly be a large opaque globe; and that all the systems of the universe, as one related system, revolve around some GRAND CENTRE common to the whole. "All those systems of worlds," says this astronomer, "resemble, though on a small scale, the solar system, inasmuch as in each the stars of which it is composed revolve round a common centre, in the same manner as the planets and comets revolve round the sun. It is even probable that several individual systems concur in forming more general systems, and so on. Such, for example, as are comprehended in the Milky Way, will make component parts of a more enlarged system; and this way will belong to other milky ways, with which it will constitute a whole. If these last are invisible to us, it is by reason of their immense distance. It would not be at all astonishing, if milky ways, situated still farther from us in the depths of the heavens, should make no impression on the eye whatever." Again: "The sum of the milky ways taken together have their com-

mon centre of revolution; but how far soever we may thus extend the scale, we must necessarily stop at last; and where? At the centre of centres, at the centre of creation, which I should be inclined to term the capital of the universe, inasmuch as thence originates motion of every kind, and there stands the great wheel in which all the rest have their indentation. From thence the laws are issued which govern and uphold the universe, or, rather, there they resolve themselves into one law of all others the most simple. But who would be competent to measure the space and time which all the globes, all the worlds, all the worlds of worlds, employ in revolving round that immense body—the Throne of Nature and the Footstool of the Divinity! What painter, what poet, what imagination is sufficiently exalted to describe the beauty, the magnificence, the grandeur of this source of all that is beautiful, great, magnificent, and from which order and harmony flow in eternal streams through the whole bounds of the universe!"

The discoveries made by Sir W. Herschel in reference to the nebulæ have in part realized some of the views suggested by Lambert in regard to the general arrangements of the systems of the universe. They afford convincing evidence that the stars are not dispersed, as it were, at random, in a kind of magnificent confusion, but are distributed systematically, in immense clusters, throughout the regions of boundless space.

There are various forms and classes of nebulæ which we shall notice in the sequel, but they may all be reduced to two great classes—the *resolvable* and *irresolvable*; that is, those which may be resolved into clusters of stars by powerful telescopes, and those which no telescope hitherto constructed has yet been able to resolve into starry groups.

Prior to Sir W. Herschel's observations on the nebulæ, about a hundred of these objects had been descried in different parts of the heavens, of which an account had been given by Messier, as formerly stated. About 2000 more were afterward discovered by the unwearied exertions of our British astronomer, a description of which was inserted at different periods in the Philosophical Transactions. The places of these were afterward computed from his observations, and arranged into a catalogue, in the order of right ascension, by his sister, Miss Caroline Herschel, a lady singularly eminent

for her astronomical knowledge, who assisted him in all his sidereal labours and discoveries, and was herself a discoverer of several interesting celestial phenomena, particularly comets. Her illustrious nephew, Sir John Herschel, read a paper before the Royal Society in November, 1833, in which he gives the places of 2500 nebulæ, or clusters of stars, of which 500 were detected by his own observations, the rest having been accurately determined by his father. Besides these, more than 500 nebulæ have been discovered in the southern hemisphere of the heavens, of which the Magellanic clouds are the most remarkable. They are three in number, two of them being near each other; the largest is at a considerable distance from the south pole, but the other two are only eleven degrees distant. To the naked eye they appear like portions of the Milky Way.

These nebulæ have great variety of forms: some are comparatively bright, and others so obscure as to render it difficult to detect them in the field of the telescope, or to ascertain their shape. Some of them appear round, some oval, and others of a long elliptic shape; some exhibit an annular form, like luminous rings, and others like an ellipsis with a dark space in the centre; but the greater number approximate to a roundish form. Of the 103 nebulæ inserted in Messier's list, eighteen were known at the time to consist of small stars; but Sir W. Herschel afterward found twenty-six more of them to consist purely of clusters of stars, eighteen of small stars accompanied with nebulosity, and the remainder not resolvable into stars by the highest powers of his telescopes. It is evident that these objects, however apparently small and obscure, must be bodies of *immense magnitude*, when we take into consideration the vast distance at which they must be placed from our globe. The following are Sir W. Herschel's views on this point:

"My opinion of their size is grounded on the following observations: There are many round nebulæ of about five or six minutes in diameter, the stars of which I can see very distinctly; and on comparing them with the visual ray calculated from some of my long gauges, I suppose, by the appearance of the small stars in those gauges, that the centres of these round nebulæ may be 600 times the distance of Sirius from us." He then goes on to show that the stars in such nebulæ are probably twice as much condensed as those of our

system, otherwise the centre of it would not be less than 6000 times the distance of Sirius, and that it is possibly much underrated by supposing it only 600 times the distance of that star. "Some of these round nebulæ have others near them, perfectly similar in form, colour, and the distribution of stars, but of only half the diameter; and the stars in them seem to be doubly crowded, and only at about half the distance from each other. They are indeed so small as not to be visible without the utmost attention. I suppose these miniature nebulæ to be at double the distance from the first. An instance equally remarkable and instructive is a case where, in the neghbourhood of two such nebulæ as have been mentioned, I met with a third similar, resolvable, but much smaller and fainter nebula. The stars of it are no longer to be perceived; but a resemblance of colour with the former two, and its diminished size and light, may well permit us to place it at full twice the distance of the second, or about four or five times the distance of the first; and yet the nebulosity is not of the milky kind, nor is it so much as difficultly resolvable or colourless. Now in a few of the extended nebulæ, the light changes gradually, so as from the resolvable to approach to the milky kind; which appears to me an indication that the milky light of nebulæ is owing to their much greater distance. A nebula, therefore, whose light is perfectly milky, cannot well be supposed to be at less than six or eight thousand times the distance of Sirius; and though the numbers here assumed are not to be taken otherwise than as very coarse estimates, yet an extended nebula which in an oblique situation, where it is possibly foreshortened by one half, two thirds, or three fourths of its length, subtends a degree or more in diameter, cannot be otherwise than of a *wonderful magnitude*, and may well OUTVIE OUR MILKY WAY IN GRANDEUR."

It appears to be a very natural conclusion, that the nebulæ which are perfectly similar in form, colour, and the distribution of stars, but only of half the diameter, and the stars doubly crowded, are about *double the distance from the first*. And if the distance of the larger nebulæ, whose stars are distinctly seen, be at least 600 times the distance of Sirius, as there is every reason to believe, then the distance of those which are only half the diameter must be about 1200 times the distance of that star; that is, at the very least, 24 000,000,000,000,000, or twenty-four thousand billions of miles. But the nebulæ

whose light is "perfectly milky," or so far removed from us that the stars of which they are composed cannot be separately distinguished, may be justly considered as seven thousand times the distance of Sirius, or, in numbers, 168,000,000,000,000,000, or one hundred and sixty-eight thousand billions of miles! a distance of which we can have no distinct conception. Light, notwithstanding its amazing velocity, would be nearly thirty thousand years ere it could fly from such nebulæ to the earth; and a cannon ball, with its utmost velocity, would require more than *thirty-eight thousand millions* of years before it could move over an equal space. Since the distance of these nebulæ is so immense, and since those which are among the largest and nearest are found by actual observation to be composed of countless numbers of stars, leaving us no room to doubt that the most distant are also immense systems of stars, how great must be *the magnitude*, and how inexpressible the grandeur, of the numerous luminaries of which they are composed!

I have stated above that more than three thousand nebulæ have already been discovered, and whose places in the heavens have been accurately determined, so that those who have access to powerful telescopes may have an opportunity of observing the greater part of them. From all the observations made by Sir W. Herschel, he is of opinion that our nebula, or the Milky Way, is *not* the most considerable in the universe; and he points out some very remarkable nebulæ which in his opinion cannot be less, but are probably *much larger*, than that of which our own sun and system form a part. Now, on these grounds let us consider what must be the extent and magnitude of only the *visible* universe. Supposing the number of stars composing the Milky Way to be ten millions, which is only half the number formerly assigned (p. 146), and that each of the nebulæ at an average contains the same number; supposing, farther, that only two thousand of the three thousand nebulæ are resolvable into clusters of stars, and that the other thousand are masses of shining fluid not yet condensed into distinct luminous globes; the number of stars or *suns* comprehended in that portion of the firmament which is within the reach of our telescopes would be 20,000,000,000, or *twenty thousand millions*, which is twenty millions of times the number of all the stars visible to the naked eye.

Great as this number is, and magnific nt and overpowering

as the ideas are which it suggests of the extent of creation, yet these vast assemblages of systems may be no more than as a single nebula to the whole visible firmament, or even as a grain of sand to the whole earth, compared with what lies beyond the range of human vision, and is hid from mortal eye in the boundless and unexplored region of immensity! Beyond the boundaries of all that will ever be visible to the inhabitants of our globe, an infinite region exists, in which we have every reason to believe the Deity sits enthroned in all the grandeur of his overflowing goodness and omnipotence, presiding over innumerable systems, far surpassing in magnificence what "eye hath yet seen" or the most brilliant intellect can conceive. For we ought never for a moment to surmise that the operations of Almighty Power are exhausted at the point where the efforts of genius and art can no longer afford us assistance in tracing the footsteps of the Divinity throughout the mysterious regions of infinitude; nor should we ever suppose that man, placed on such a diminutive ball as the earth, and furnished with powers of so limited a nature as those with which he is now invested, will ever be able to grasp the dominions of Him who fills immensity with his presence, and "whose ways are past finding out."

Section II.—*On the various kinds of Nebulæ.*

I have already alluded to the different shapes or forms of nebulæ. These objects, on account of their appearing with different degrees of lustre, and assuming a great variety of shapes and modifications, have been arranged into different classes.

1. The first class is that of *clusters of stars*, in which the separate stars are clearly distinguished by good telescopes. This class is again divided into *globular* clusters, or those which appear of a roundish form, and somewhat compressed towards the centre; and *irregular* clusters, or those which are neither circular nor elliptical, but of a somewhat indefinite or angular form. These last are generally less rich in stars, and less condensed towards the centre, and are likewise less definite in their outline, so that their termination in many cases cannot be distinctly perceived. In some of them the stars are nearly all of the same size, in others extremely different; and "it is no uncommon thing," says Sir J. Herschel,

41 42 43 44 45 46

"to find a very red star, much brighter than the rest, occupying a conspicuous situation in them." Sir W. Herschel regards these as globular clusters in a less advanced state of condensation, conceiving all such groups as approaching, by their mutual attraction, to the globular figure, and assembling themselves together from all the surrounding region, under laws of which we have no other proof than the observance of a gradation by which their characters shade into one another, so that it is impossible to say where one species ends and the other begins. Fig. 41, formerly referred to, represents one of the globular clusters in the constellation Hercules. Fig. 42 is a view of a curious but somewhat irregular group, seen in the southern hemisphere, as sketched by Mr. Dunlop, at Paramatta, New South Wales. It is the 30 Doradûs, or Xipheas, and is rather a singular object, but evidently a large cluster of stars, presenting two or three very condensed strata, as if they were crowded to excess by an immense confluence of stars.

2. Another class is that termed *resolvable nebulæ*, or those which lead us to suppose that they consist of stars which would be separately distinguishable by an increase of light and magnifying power in the telescope. These may be considered as clusters too remote to be distinctly seen, the stars composing which are either too faint in their light or too small in size to make a definite impression upon the organs of vision. They are almost universally round or oval, which is supposed to be owing to their loose appendages and irregularities of form being extinguished by their distance, the general figure of the central or more condensed parts being only discernible. "It is under the appearance of objects of this character," says Sir J. Herschel, "that all the greater globular clusters exhibit themselves in telescopes of insufficient optical power to show them well; and the conclusion is obvious, that those which the most powerful can barely render *resolvable*, would be completely *resolved* by a farther increase of instrumental force."

3. Besides the above, there is an immense variety of nebulæ, *properly so called*, which no telescopes have hitherto been able to resolve into stars, and which is supposed to be a species of matter diffused throughout infinite space, in various portions and degrees of condensation, and which may, in the course of ages, be condensed into stars or starry systems. The follow-

ing is a description of some of the more remarkable varieties of this class of nebulæ.

Fig. 43 represents a nebula of an elliptical or spindle-like form. It is visible to the naked eye in a clear night, when the moon is absent, and has sometimes been mistaken for a small comet. It appears like a dull, cloudy, undefined spot upon the concave of the firmament, and has sometimes been compared to the light of a small candle shining through horn. Its central parts appear brightest, but its light gradually fades towards each extremity. A few small stars appear adjacent to it, and even within its boundaries, but it appears pretty evident that they have no *immediate* connexion with the nebula. Its form, as here delineated, may be seen with a telescope of moderate power, but no telescope hitherto constructed, even with the highest powers that could be applied, has yet been sufficient to resolve it into stars. In size, it is nearly half a degree long, and 12 or 15 minutes broad. Though the figure of this object appears oval or elliptical, it is not unlikely that it is in reality nearly of a globular figure, and that its oval appearance is owing to its position with regard to our eye. This nebula is situated in the girdle of Andromeda, within a degree or two of the star ν of that constellation. It is about 15° nearly west from *Almaach*, and 8° north by west of *Merach*, with which stars it forms nearly a right-angled triangle. It may be seen in a northwesterly direction in the evenings of the months of January, February, and March, at a considerable elevation. It comes to the meridian about the middle of November, at nine o'clock in the evening Its right ascension is 0^h 33′, and north declination 40° 20′. This nebula may be considered as a representative, on a large scale, of a numerous class of nebulæ, which increase more or less in density towards the central point. The representation of it in the plate is somewhat longer and narrower than it appears through a telescope magnifying 140 times.

Fig. 44 represents a kind of elliptical nebula, with a vacancy of a lenticular form in the centre. It is pretty evident that such nebulæ are in reality large rings, which appear of an oval or lenticular form in consequence of their lying obliquely to our line of vision. This is undoubtedly a large starry system, comprising perhaps millions of stars, at such a distance that their combined light appears only like a faint nebula. It probably is not much unlike the form of our Milky Way in which

the sun is situated. Its right ascension is 2^h 12′, and north decl. 41° 35′. It lies near γ Andromedæ, or *Almaach*, about 4° to the eastward of that star, nearly in a line between it and *Algol*, in the head of Medusa, and about 19° east from the nebula represented in Fig. 43.

Fig. 45 is a representation of an *annular* nebula, which may be seen with a telescope of moderate power. It does not occupy so much space in the heavens as the preceding nebulæ, but it is well defined, and has the appearance of a flat, solid ring. It is not perfectly circular, but somewhat elliptical, the conjugate axis of the ellipse being to the transverse nearly in the proportion of 4 to 5. The opening occupies about half its diameter, and is not entirely dark, but filled up with a very faint, hazy light uniformly spread over it. Its light is not of a pure milky white, but is somewhat mottled in its appearance near the exterior edge. This curious phenomenon, like the preceding, is doubtless an immense stellar system, situated at an immeasurable distance in the profundity of space. It is situated in the constellation of Lyra, exactly half way between the stars β and γ, so that its position may be found by common observers without any difficulty. Its right ascension is 18^h 47′, and north declination 32° 49′. The following cut (fig. 46*) represents some of the principal stars in the constellation of the Lyre. The largest star near the upper part is *Vega*, a bright star of the first magnitude; the next larger star, south by east of which is β; and the other star of the same magnitude to the southeast is γ; between which is the annular nebula, about 7½° from Vega.

Fig. 46 represents an object somewhat similar to the above. It is situated between the constellations Anser and Cygnus, about 9½° south from the star γ Cygni, and 17° east from the phenomenon described above.* Its right ascension is 20^h 9′,

* It may not be improper here to remark, once for all, that the bearings or directions of the stars from one another, given here and in other parts of this volume, are strictly applicable only when the principal star, from which the bearings are stated, *is on or near the meridian*. When in other positions, they will appear, to a common observer, to have different bearings; for example, the star *Vega*, or Lyra, in the above figure, when about 50° or 60° above the western horizon, will appear at an equal altitude as the star β, southwest by south of it; and when about 30° or 40° above the eastern horizon, the two stars will appear, the one directly above or below the other. This difference in the apparent directions of the stars from each other is most observable in those which are near the pole; for example, the stars of the Great Bear appear in one

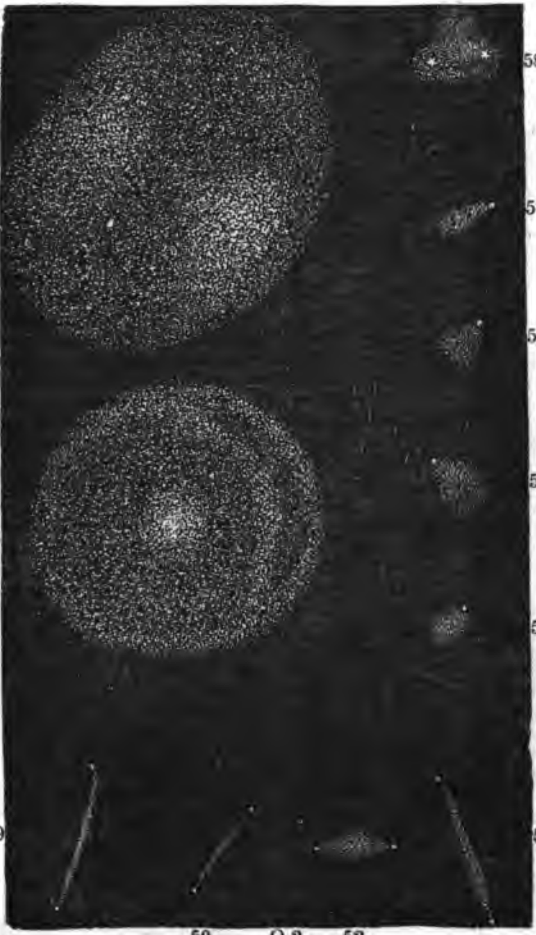
Fig. 46.*

North.

and north declination 30° 3′. It comes to the meridian about the 10th of September, at nine o'clock in the evening.

The opposite page contains representations of several other kinds of nebulæ, some of which are extremely curious and singular. Fig. 47 is a very singular and wonderful object. It has the shape of a dumb-bell or hourglass of bright matter, surrounded by a thin, hazy atmosphere; the two connected hemispheres, and the space which connects them, are beautiful and pretty bright. The oval is completed by a space on each side, which is more dim and hazy than the two hemispheres. The whole has an oval form, like that of an oblate spheriod. The southern hemisphere is somewhat denser than the northern, and there are one or two stars in it. It appears evidently to be a dense collection of stars at an immeasurable distance from the region in which we reside, and leads us to form an idea of the endless diversities of shape and form among those countless assemblages of stars with which the

part of their revolution *west* from the pole, and in another part of their course *east* of it. These and other circumstances require to be attended to, in order to find particular stars by their bearings from one or more principal stars.



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universe is replenished. This nebula is situated in right ascension 19h 52′, north declination 22° 16′; in the breast of Anser et Vulpecula, about midway between Albireo in the Swan, and the principal stars of the Dolphin, about three or four degrees north of Sagitta, a star of the fourth magnitude.

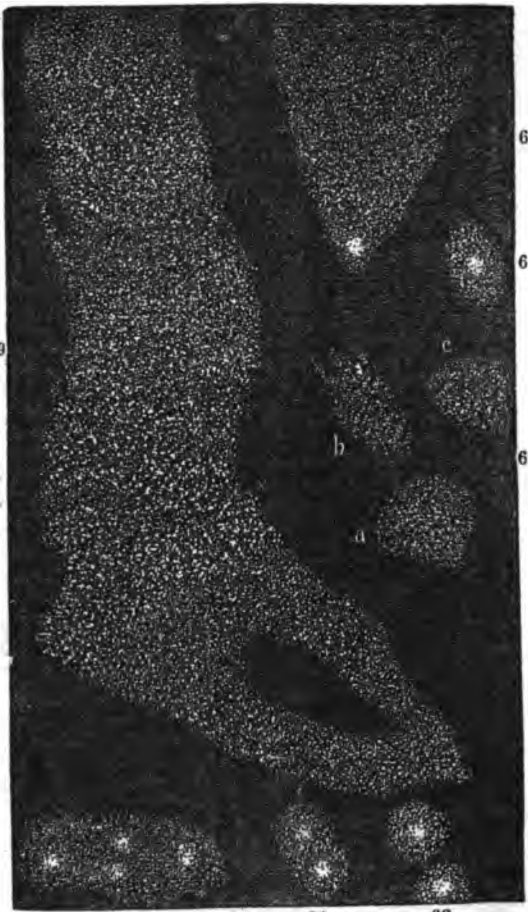
Fig. 48 is likewise a very remarkable object. It consists of a bright round nucleus or central part, surrounded at a great distance by a nebulous ring. This ring appears split through nearly the greater part of its circumference, the two portions of which being separated at about an angle of 45°. This nebula lies near the remotest boundaries to which our telescopes can carry us. It has never been resolved into stars by the highest powers that have yet been applied; but there is little doubt that it is a grand scheme of sidereal systems, perhaps exceeding our Milky Way in number and magnificence. It is, indeed, supposed to bear a more striking resemblance to the system of stars in which the sun is placed than any other object which has yet been discovered in the heavens, as may be perceived by turning to figure 39 (p. 156), which represents Sir W. Herschel's scheme of the Milky Way; and hence Sir John Herschel describes it as "a brother system, bearing a real physical resemblance and strong analogy of structure to our own." This object, dim and distant as it may appear through our telescopes, and utterly invisible as it is to the unassisted eye, may be considered as a kind of universe in itself, ten thousand times more grand and extensive than the whole creation was supposed to be in the infancy of astronomy. Like the preceding nebula, it shows us what singular varieties of structure are to be found in the systems which compose the universe, and, at the same time, it exhibits a certain resemblance to another system of which we form a part; and perhaps something similar, though not precisely of the same form and arrangement, may be found in other parts of the sidereal heavens. This phenomenon is situated near the back of Asterion, about five degrees south by west of *Benetnasch*, the last star in the tail of the Great Bear; between which star and the nebula there is a small star of the fifth magnitude, nearer to the nebula than to Benetnasch. Its right ascension is 13h 22′, and north declination 46° 14′.

Figures 49, 50, 52, 53, 54, 55, 56, 57, and 58, represent some specimens of *nebulous stars*, or of nebulæ connected with very small stars.

Fig. 49 shows a nebulosity, or something like a nebulous stream, extending from one small star to another, as if there was a communication between them. The next three figures are representations of similar phenomena. In fig. 52, the nebulous substance appears much broader than in the others, though this may possibly be owing to the nebula in its greatest extent being presented to our line of vision.

Figs. 54, 55, 56, are very small stars, with faint and small nebulæ attached to them in the shape of a puff. Fig. 57 is a small star, with a small, faint, fan-shaped nebulosity joined to it. Fig. 58 represents two considerable stars involved in a very faint nebulosity of three or four minutes in extent. What this nebulous substance in reality is, or what connexion it may have with the stars which appear in its vicinity, it is difficult to conjecture. It is a species of nebulæ which does not appear to be resolved into stars, and therefore may be regarded as a distinct luminous substance, diffused throughout the different regions of the universe, subserving some important designs in the physical economy of creation of which we are ignorant. Specimens of some of these phenomena will be found in the following situations: 1. Right ascension 20^h 56′, north declination 11° 24′; a little to the east of the cluster of stars called the Dolphin. 2. Right ascension 8^h 46′, north declination 54° 25′; about seven degrees northwest of the star *Theta* of the Great Bear. 3. Right ascension 12^h 51′, north declination 35° 47′; about four degrees south of the star *Cor Caroli*, the principal star in the Greyhounds. 4. Right ascension 6^h 30′, north declination 8° 53′; which is in the head of Monoceros, or the Unicorn, about eleven degrees east of Betelguese, in the right shoulder of Orion, and about seven degrees due south of γ Gemini, which is in the left foot of one of the Twins.

Figs. 59 to 65 represent a few specimens of objects which come under the denomination of *extensive diffusive nebulosities*. These phenomena were very little noticed till lately, and can only be perceived by telescopes of large aperture, which collect a great quantity of light. In adverting to one of these objects, Sir W. Herschel describes it as follows: "Extreme faint branching nebulosity; its whitishness is entirely of the milky kind, and it is brighter in three or four places than the rest; the stars of the Milky Way are scattered over it in the same manner as over the rest of the heavens.



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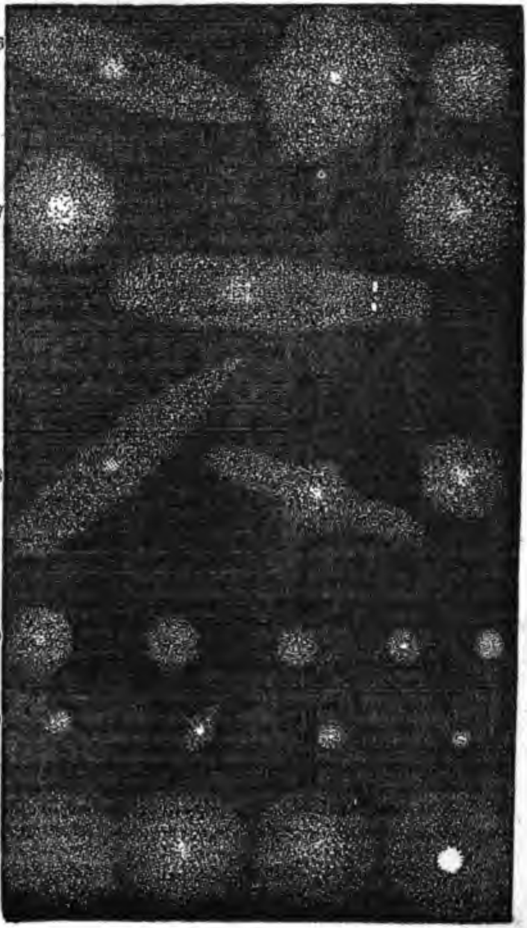

Its extent in the parallel is nearly one degree and half, and in the meridional direction about fifty-two minutes." It appears that this diffused nebulosity is very extensive; for, of fifty-two nebulæ of this description which had never been before observed, Herschel found them to occupy no less than 152 square degrees. A specimen of an extensive diffusive nebula of this description is represented in fig. 59.

Sir W. Herschel has presented us with fourteen specimens related to this class, of what he terms *nebulosities joined to nebulæ*, one of which is represented in fig. 60, where a bright nebulous speck is connected with a faint nebulosity, which seems to proceed from it as from a central point, increasing in breadth, in proportion to the distance, till it terminates in a kind of irregular margin. Fig. 61 represents what is called a *milky nebula with condensation*. It appears to be a roundish nebula, condensed towards the central parts. It is natural to suppose, when we see a gradual increase of light, that there is a condensation of the substance which produces it in the space which appears brightest, or, at least, that the luminous substance is *deeper* in the brighter space. Some of the nebulosities of this class are not always extensively diffused, but are sometimes met with in detached collections, near to each other, but completely separate, as represented at *a*, *b*, *c*, fig. 62.

A diffused nebulosity of this kind may be seen about six or seven degrees due east from the star *Zeta* Cygni, near the back or tail of Anser. Its right ascension is 20h 38′, and north declination 30° 6′. Another, whose right ascension is 20h 49′, and north declination 31° 3′, is found about three or four degrees northwest of *Zeta* Cygni, and within two or three degrees of the preceding.

Figures 63, 64, and 65 are representations of nebulæ which are brighter in more than one place, which appearance is supposed to be owing to so many predominant seats of attraction, owing to a superior preponderance of the nebulous matter in those places causing a division of it, from which will arise three or four distinct nebulæ.

Figs. 66 to 71 are representations of nebulæ of various descriptions. The three upper figures, numbered 66, are nebulæ that are *suddenly much brighter in the middle*. A nucleus to which these nebulæ seem to approach is considered as indicating consolidation; and that, should we have reason to conclude that a solid body can be formed of condensed nebulous

matter, the nature of which has been chiefly deduced from its shining quality, we may possibly be able to view it with respect to some other of its properties. The three figures, No. 67, represent *extended nebulæ and round nebulæ, that show the progress of condensation.* These nebulæ appear farther condensed than the preceding, and appear surrounded with the rarest nebulous matter, which, not having as yet been consolidated with the rest, remains expanded about the nucleus in the shape of a very extended atmosphere. The three figures in the third row from the top of the plate, marked No. 68, and the first figure to the left hand of No. 69, represent nebulæ which are almost of a uniform light, and nebulæ that draw progressively towards a period of final condensation. "In the course of the gradual condensation of the nebulous matter," says Sir W. Herschel, "it may be expected that a time must come when it can no longer be compressed, and the only cause which we may suppose to put an end to the compression is, when the consolidated mass assumes hardness. From the size of the nebulæ, as we see them at present, we cannot form an idea of the original bulk of the nebulous matter they contain; but let us admit, for the sake of computation, that the nebulosity of a certain nebula, when it was in a state of diffusion, took up a space of ten minutes in every cubical direction of its expansion, then, as we now see it collected into a globular compass of less than one minute, it must of course be more than 1900 times denser than it was in its original state. This proportion of density is more than double that of water to air."

The small nebulæ represented in No. 70 are *stellar nebulæ,* which approach to the appearance of stars, and one or two of doubtful character. The four figures marked No. 71 represent separate views of the gradual condensation of the nebulous substance. In these we may evidently perceive a striking gradation in the light and brilliancy of the central parts. The figure on the left-hand side represents an object nearly in its original state of nebulosity; the next towards the right appears considerably condensed towards the central parts; the third figure represents a condensation still greater; and the one on the right hand exhibits a condensation nearly complete, or a huge luminous body surrounded with a lucid atmosphere. Each of these is the representative of an extensive class of objects of this description.

Section III.—*On Planetary Nebulæ.*

This designation is given to a class of nebulæ which bear a very near resemblance to planetary disks when seen through telescopes. But, notwithstanding their planetary aspect, some small remaining haziness, by which they are more or less surrounded, evinces their nebulous origin. They are somewhat extraordinary objects, with round or slightly oval disks, in some instances quite sharply terminated, in others a little hazy at the borders, and of a light exactly equable, or only a very little mottled, which in some of them approaches in vividness to the light of actual planets. The following are some of Sir W. Herschel's remarks on these bodies:—If we should suppose them to be single stars with large diameters, we shall find it difficult to account for their not being brighter, unless we should admit that the intrinsic light of some stars may be very much inferior to that of the generality, which, however, can hardly be imagined to extend to such a degree. We might suppose them to be comets about their aphelion, if the brightness as well as magnitude of their diameters did not oppose this idea; so that, after all, we can hardly find any hypothesis so probable as that of their being nebulæ; but then they must consist of stars that are compressed and accumulated in the highest degree. At a subsequent period, Sir William remarks, "When we reflect on the circumstances connected with these bodies, we may conceive that, perhaps, in progress of time, these nebulæ, which are already in a state of compression, may be still farther compressed, so as actually to become stars. It may be supposed that solid bodies, such as we suppose the stars to be, from the analogy of their light with that of our sun when seen at the distance of the stars, can hardly be formed of a condensation of nebulous matter; but if the immensity of it required to fill a cubical space which will measure ten minutes, when seen at the distance of a star of the eighth or ninth magnitude, is well considered and properly compared with the very small angle our sun would subtend at the same distance, no degree of rarity of the nebulous matter to which we have recourse can be any objection to the solidity required for the construction of a body of equal magnitude with our sun."

The nature of these nebulæ is involved in considerable dark-

ness and mystery. As in the case of some of the other species of these phenomena, so in this, the mind feels unable to form any definite or satisfactory conceptions on the subject. The following remarks of Sir J. Herschel comprise most of what can be stated, in the mean time, on this subject: "Whatever be their nature, they must be of enormous magnitude. One of them is to be found in the parallel of ν Aquarii, and about five minutes preceding that star. Its apparent diameter is about twenty seconds. Another, in the constellation Andromeda, presents a visible disk of twelve seconds perfectly defined and round. Granting these objects to be equally distant from us with the stars, their real dimensions must be such as would fill, on the lowest computation, *the whole orbit of Uranus*. It is no less evident that, if they be solid bodies of a solar nature, the intrinsic splendour of their surfaces must be almost infinitely inferior to that of the sun's. A circular portion of the sun's disk, subtending an angle of twenty seconds, would give a light equal to 100 *full moons*, while the objects in question are hardly, if at all, discernible with the naked eye. The uniformity of their disks, and their want of apparent central condensation, would certainly augur their light to be merely superficial, and in the nature of a hollow superficial shell; but whether filled with solid or gaseous matter, or altogether empty, it would be a waste of time to conjecture."

In this description there is nothing which strikes the mind with such astonishment as the *enormous magnitude* of these planetary nebulæ. A globular body which would fill the orbit of Uranus would contain 24,429,081,600,000,000,000,000,000,000, or more than twenty-four thousand *quartilions* of solid miles. The solid contents of the sun is about 357,000,000,000,000,000, or three hundred and fifty-seven thousand *billions* of cubical miles. If the former number be divided by the latter, the quotient will be 68,428,800,000, showing that the nebula in question would contain within its circumference sixty-eight thousand, four hundred and twenty-eight millions, and eight hundred thousand globes as large as the SUN. A body of such a bulk is more than thirty-four billions, two hundred thousand millions of times larger than all the primary planets and their satellites which belong to our system. What is the special destination of such huge masses of matter, or what important designs they subserve in the physical and moral arrangements of the Governor of the universe, it is be-

yond our power, in the mean time, to form even a probable conjecture. Future generations may perhaps be enabled to throw some light on this subject, though it is probable that the nature, properties, and ultimate designs of many such objects will only be fully disclosed throughout the revolutions of that interminable duration which succeeds the short span of human existence; but of this we may rest assured, that they are *not useless* masses of materials in the universe, but are subservient to purposes worthy of Him whose wisdom is infinite and whose understanding is unsearchable.

The four figures towards the right hand of the plate, marked No. 69, represent some specimens of planetary nebulæ. One of those bodies may be seen near the star *ν* Aquarii, as above stated. Its right ascension is nearly 20^h 52′, and its south declination about 12° 26′. It lies north by west of the star *Deneb Algedi*, at the distance of about ten degrees. Other nebulæ of this description may be found near the following stars: 3 *p* Sagittæ, 14 Andromeda, 63 *b* Crateris, 61 *g* Sagittæ, 10 Camelopardus, 36 Ursæ Majoris, 6 Navis, and 6 Draconis. About three minutes west from the star 16 *c* Cygni the following phenomenon is found: A bright point a little extended, like two points close to each other. It is as bright as a star of the eighth or ninth magnitude, surrounded by a very bright milky nebulosity, suddenly terminated, having the appearance of a planetary nebula with a lucid centre. The border is not well defined; it is perfectly round, and about one minute and thirty seconds in diameter. This is a beautiful phenomenon, and of a middle species between the planetary nebulæ and nebulous stars.

Sir John Herschel, during his late residence at the Cape of Good Hope, is said to have discovered several new and singular objects in the southern hemisphere, some of them bearing a certain relation to the objects now described; among others, he is said to have detected a beautiful planetary nebula, which presents a perfectly sharp, well-defined disk of uniform brightness, exhibiting the exact appearance of a small planet with a satellite near its margin. The regular compactness and globular form of such objects seem to indicate that they are bodies *sui generis*, neither collections of distinct stars nor exactly of the same nature with the other masses of nebulous matter dispersed through the heavens. They seem to present a view of an immense system already completed, but of what

nature it would be vain to conjecture. Another phenomenon of this kind is stated as being of an extraordinary nature, on account of the *blue* colour which its light exhibits. He has likewise discovered a close double star involved in the centre of a nebulous atmosphere, which is considered as a new and singular object.

Section IV.—*On the nebula in Orion.*

One of the largest and most remarkable nebulæ in the heavens is that which is found in the constellation of Orion. When a common observer looks at that constellation, the first object that arrests his attention is the three brilliant stars equidistant from each other in a straight line, which is called the *belt* of Orion. Immediately below these, hanging down, as it were, from the middle of the belt, three small stars at nearly equal distances are perceived, which are termed *the sword.* On directing the naked eye to the middle star of the three, the observer perceives something that has the appearance of a small star, but not well defined; this is the great nebula of Orion; of which, however, he can form no definite conception till his eye be assisted by optical instruments. With a common one-foot pocket achromatic telescope the nebulosity may be plainly perceived; but the higher the magnifying power, and the larger the aperture of the object glass, the more brilliant and distinct does this phenomenon appear, along with a number of small stars connected with it, which are quite invisible to the unassisted eye.

The first who discovered this phenomenon was the celebrated Huygens, who gave the following description of it in his *Systema Saturnium:* "Astronomers place three stars close to each other in the sword of Orion; and when I viewed the middlemost with a telescope in the year 1656, there appeared, in the place of that one, twelve other stars; among these, three that almost touch each other, and four more besides appeared twinkling as through a cloud, so that the space about them seemed much brighter than the rest of the heavens, which appearing wholly blackish, by reason of the fair weather, was seen as through a certain opening, through which one had a free view into another region which was more enlightened. I have frequently observed the same appearance in the same place without any alteration; so that it is likely

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that this wonder, whatever it may be in itself, has been there from all times; but I never took notice of anything like it among the rest of the fixed stars."

Fig. 72 exhibits a view of this phenomenon as seen by Dr. Long in 1741 with a seventeen-feet refracting telescope, which appears exactly of the same shape as originally delineated by Huygens; but the apparent magnitudes of the stars connected with it are more accurately shown than in the engraved delineation of Huygens. Dr. Long says that the luminous space has sometimes appeared to him nearly of the same shape as the figure which is formed by the seven stars within it. Fig. 73 represents the same nebula, as seen by Sir W. Herschel in the year 1774 and in 1811. Its shape appears considerably different from the delineations of Huygens and Dr. Long; but the stars within and around it, which are common to both delineations, appear nearly in the same relative positions. Sir John Herschel has given a representation of this nebula, as viewed through the twenty-feet reflector at Slough, which appears considerably different from the figures to which I have referred. I have frequently viewed this phenomenon with telescopes of different sizes, particularly with a six feet and a half achromatic, having an aperture of four inches diameter, and which showed sidereal objects with great brilliancy and distinctness; but the shape of the object appeared more nearly resembling Dr. Long's representation (fig. 72) than any other delineation I have seen. A fourth star was distinctly seen in addition to the three represented by Dr. Long near the head of the opening, but smaller than the other three, and forming with them a small irregular square. The three other stars, instead of being *within* the one side of the nebula, as represented in both the figures, appeared quite beyond it, but nearly in a line with its margin. Whether this was owing to the inaccuracy of the delineation or to the actual change of the nebula I do not pretend to determine. The left-hand branch of the nebula likewise appeared considerably longer than here represented; but I cannot pretend to say what the appearance may be as seen through a twenty-feet reflecting telescope.

In forming a proper conception of this object, it is of some importance to ascertain the exact appearance it has presented at different periods, and whether there be reason to conclude that it has been subject to changes. The following is Sir J. Herschel's description of this phenomenon:

"I know not how to describe it better than by comparing it with a curdling liquid, or a surface strewed over with flocks of wool, or to the breaking up of a mackerel sky, when the clouds of which it consists begin to assume a cirrhous appearance. It is not very unlike the mottling of the sun's disk, only, if I may so express myself, the grain is much coarser and the intervals darker, and the flocculi, instead of being generally round, are drawn into little wisps. They present, however, an appearance of being composed of stars, and their aspect is altogether different from that of resolvable nebulæ. In the latter we fancy by glimpses that we see stars, or that, could we strain our sight a little more, we would see them; but the former suggests no idea of stars, but rather of something quite distinct from them."

The following are some of Sir W. Herschel's remarks on this nebula, and on the stars with which it is connected;

"In the year 1774, the 4th of March, I observed the nebulous star which is the 43d of the *Connoissance des Temps*, and is not many minutes north of the great nebulæ: but at the same time I also took notice of two similar, but much smaller, nebulous stars, one on each side of the large one, and at nearly equal distances from it. (*See* fig. 73, &c.) In 1783 I examined the nebulous star, and found it to be faintly surrounded with a circular glory of whitish nebulosity, faintly joining it to the great nebulæ. About the latter end of that year I remarked that it was not equally surrounded, but most nebulous towards the south. In 1784 I began to entertain an opinion that the star was not connected with the nebulosity of the great nebulæ of Orion, but was one of those which are scattered over that part of the heavens. In 1801, 1806, and 1810, this opinion was fully confirmed by the gradual change which happened in that great nebulæ to which the nebulosity surrounding the star belongs; for the intensity of light about the nebulous star had by this time been considerably reduced by the attenuation or dissipation of the nebulous matter, and it seemed now to be pretty evident that the star is far behind the nebulous matter, and that, consequently, its light in passing through it is scattered and deflected so as to produce the appearance of a nebulous star." .... "When I viewed this interesting object in December, 1810, I directed my attention particularly to the two nebulous stars by the sides of the large one, and found they were perfectly free from every

nebulous appearance, which confirmed not only my former surmise of the great attenuation of the nebulosity, but also proved that their former nebulous appearance had been entirely the effect of the passage of their feeble light through the nebulous matter spread out before them. The 19th of January, 1811, I had another critical examination of the same object, in a very clear view, through the forty-feet telescope; but, notwithstanding the superior light of this instrument, I could not perceive any remains of nebulosity about the two small stars, which were perfectly clear, and in the same situation where, about thirty-seven years before, I had seen them involved in nebulosity. If, then, the light of these three stars is thus proved to have undergone a visible modification in its passage through the nebulous matter, it follows that its situation among the stars is less distant from us than the largest of the three, which I suppose to be of the eighth or ninth magnitude. The farthest distance, therefore, at which we can place the faintest part of the great nebula in Orion, to which the nebulosity surrounding the star belongs, cannot well exceed the region of the stars of the seventh or eighth magnitude."

From these observations it would appear that the nebulosities connected with the great nebula are subject to certain changes, and that its distance from our system is less than that of stars of the eighth magnitude, since a portion of the nebulous matter interposes between our sight and stars of this description. But this distance must be very great. If stars of the eighth magnitude are to be considered at an average as eight times farther distant than those of the first, then this nebula cannot be supposed to be less than 320,000,000,000,000, or three hundred and twenty billions of miles from the earth. If its diameter at this distance subtend an angle of ten minutes, which it nearly does, its *magnitude* must be utterly inconceivable. It has been calculated that it must exceed 2,000,000,000,000,000,000, or two trillions of times the dimensions of the *sun*, vast and incomprehensible as these dimensions are.

This nebula has never yet been resolved into stars by the highest powers of the telescope that have yet been applied; nor is there any reason to believe that it consists of a system of stars, as is the case with many other nebulæ which appear much smaller, and are evidently more distant. It is therefore,

in all probability, a mass of self-luminous matter not yet formed into any system or systems, but of what nature it would be vain to conjecture. Whether it is more condensed than when it was first observed nearly two hundred years ago, as some have conjectured, or whether any portions of it have shifted their position, as seems to have been the opinion of Sir W. Herschel from the observations above stated, appears, on the whole, somewhat uncertain. On this point Sir J. Herschel makes the following remarks: "Several astronomers, on comparing this nebula with the figures of it handed down to us by its discoverer, Huygens, have concluded that its form has undergone a perceptible change; but when it is considered how difficult it is to represent such an object duly, and how entirely its appearance will differ even in the same telescope, according to the clearness of the air or other temporary causes, we should readily admit that we have no evidence of change that can be relied on."

The phenomenon we have now been contemplating is calculated to suggest a train of reflections and inquiries: What is the grand design in the system of nature of such an immense mass of luminosity—a mass of luminous matter to which the whole solar system is but only as a point—a mass at least twenty-nine millions of times larger than a globe which *would fill the orbit of Uranus?** Is it in a state of perfection completely answering the ultimate end of its creation, and will it remain for ever in that state? Or is it only a chaotic mass of materials progressing towards some glorious consummation in the future ages of eternity, when worlds and systems will be evolved from the changes and revolutions now going forward within its boundaries? Or may we suppose that a luminosity of so vast extent serves the purpose of a thousand suns to ten thousand of opaque globes which revolve within its wide circumference? Considering the diversified methods of Divine operation, and the vast variety of modes by which worlds are arranged and enlightened, it is not impossible, nor even improbable, that numerous worlds may be in this way illuminated with a perpetual and uninterrupted day. As there appear to be worlds connected with one sun, with two, with three, and even more suns, so there may be thousands of worlds cheered and illuminated without such a sun as

* See page 196.

ours, and with an effulgence of light which is common to them all. But on these points we shall never be able to arrive at certainty so long as we sojourn in this sublunary sphere. Suffice it to say, that such an enormous mass of luminous matter was not created in vain, but serves a purpose in the Divine arrangements corresponding to its magnitude and the nature of its luminosity, and to the wisdom and intelligence of Him whose power brought it into existence. It doubtless subserves some important purpose, even at the present moment, to worlds and beings within the range of its influence. Were we placed as near it as one half the distance of the nearest star, great as that distance is, from such a point it would exhibit an effulgence approximating to that of the sun; and to beings at much nearer distances it would fill a large portion of the sky, and appear with a splendour inexpressible. But the ultimate design of such an object, in all its bearings and relations, may perhaps remain to be evolved during the future ages of an interminable existence; and, like many other objects in the distant spaces of creation, it excites in the mind a longing desire to behold the splendid and mysterious scenes of the universe a little more unfolded.

Section V.—*On the Nebular Hypothesis.*

I have already stated that the nebulæ may be arranged into two classes, the *resolvable* and the *irresolvable*. When Sir W. Herschel commenced his observations on the nebulous part of the heavens, and for several years afterward, he was disposed to consider the nebulæ in general to be no other than clusters of stars disguised by their very great distance; but a long experience and better acquaintance with the nature of nebulæ convinced him that such a principle ought not to be universally admitted, although a cluster of stars may undoubtedly assume a nebulous appearance when it is too remote for us to discern the stars of which it is composed. When he perceived that additional light had no effect in resolving certain nebulæ into stars, he was forced to the conclusion that, though milky nebulæ may contain stars, yet there are also nebulosities which are not composed of them nor immediately connected with them.

Hence astronomers have been constrained to admit the existence of a certain species of fine luminous matter, distinct

from stars, or planets, or any other materials existing around us, which is diffused in immense masses throughout the spaces of the universe. The large nebula in Orion, described above, is considered as one of the most striking evidences that such a substance is distributed throughout the sidereal regions; for the whole light and power of Herschel's forty-feet telescope, though four feet in aperture, was insufficient to resolve it into stars, although from certain circumstances it appears to be one of the nearest, as it is one of the brightest, of those nebulous masses. It has therefore become a subject of interesting inquiry, "What are those huge masses of unformed matter we call the nebulæ? and what purposes do they serve in the economy of creation?"

It is an opinion now very generally entertained, that the self-luminous matter to which we refer is the chaotic materials out of which new suns or worlds may be formed, and that it is gradually concentrating itself by the effect of its own gravity, and of the circular motions of which it may be susceptible, into denser masses, so as ultimately to effect the arrangement and establishment of sidereal systems. It is argued that this opinion is highly probable, from the consideration that we find the nebulæ in almost *every stage of condensation*. Such nebulæ as are represented in figures 59 and 62 are viewed as consisting of nebulous matter in its rudest and most chaotic state; and figures 63, 64, 65, and also figures 66, 67, 68, as similar matter in a state of progress towards condensation. The four figures marked 71 are considered as specimens of this gradual condensation, in which the progress may be traced from the left-hand figure to the right. It has even been maintained by some late writers on this subject, that this, in all probability, is the mode in which the different systems of the universe were gradually brought into the state in which we now behold them, and that the sun and planets of the system to which we belong derived their origin from a similar cause; and it has likewise been attempted to connect the geological changes in the structure of our globe with the operation of a principle or law by which such a thin, filmy substance as a nebula was condensed into such a heterogeneous mass of solidity as we find in the constitution of the terraqueous globe; and it has been insinuated that the zodiacal light is a portion of the original nebula of which the sun and planets were formed, and a presumptive evidence that the

nebular hypothesis is true. According to these theories, the sun is still to be considered as a nebulous star in a high state of condensation, and may exhibit such an appearance when viewed from a neighbouring system.

Such conclusions, to say the least, are obviously premature. We know too little, in the mean time, of the nature of that nebulous matter which is dispersed through the heavens, or of the motions with which its particles may be endued, to be able to determine its susceptibility of being condensed and arranged into suns and planets. We have never yet seen the same nebula progressing from one stage of condensation to another, from a chaotic to a state of organization; nor is it likely we ever shall, even supposing the hypothesis to be well-founded, as an indefinite number of years, or even of ages, must be requisite before such a revolution can be accomplished. Yet the observations of future astronomers on this department of the sidereal heavens may tend to throw some additional light on this mysterious subject.

It forms no conclusive argument, however, against this hypothesis, that it is difficult to conceive how a fluid of a nature so apparently rare can ever be condensed to the hardness of a planet or a sun; for if we suppose a nebulosity in its most diffused state to be twenty minutes in diameter, and to be compressed by central attraction and rotary motion till it become only one minute in diameter, the ratio of its density in the latter state compared with that of the former would be as eight thousand to one, since spheres are to each other as the cubes of their diameters. Suppose its density in the first state were equal to that of atmospheric air; its density, when compressed in the proportion supposed, would be nine times heavier than water, which is nearly equal to the weight of silver, and twice the average density of our globe; but if such a process be going on in any of these bodies, numerous ages must elapse before such a consolidation can be effected, for no sensible change appears to have taken place during the period in which such bodies have come under our observation.

Nor do we conceive that this hypothesis is inconsistent with what we know of the attributes and operations of the Almighty; for all the movements and changes going on in our terrestrial system and throughout the universe, are the effects of certain laws impressed upon matter by the hand of the Creator, by the uniform operation of which his wise and beneficent

designs are accomplished. If, then, it forms a part of his designs that new suns and systems shall be formed to diversify the spaces of immensity, and if he has created huge masses of subtile luminous matter, and endued them with certain gravitating powers and rotary motions for this purpose, his almighty agency and infinite wisdom may be as clearly and magnificently displayed in this case as if a system of worlds, completely organized, were to start into existence in a moment. Perhaps the gradual evolution of his designs in such a case might afford matter of admiration and enjoyment to certain orders of superior beings who are privileged to take a near view of such stupendous operations. But, supposing such physical processes going forward, we must necessarily admit that *a direct interference of the Deity is necessary before such worlds*, after being organized, *can be replenished with inhabitants*; for matter and motion, by whatever laws they may be directed, cannot be supposed to produce the organization of a plant or an animal, much less of a rational being, whose intellectual principle and faculties must be communicated by the immediate "inspiration of the Almighty." To suppose otherwise would be virtually to adopt a species of atheism.

All that we require on this point is some more direct and decisive proofs of the validity of the hypothesis we are now considering; and, till such proofs be elicited, we are not warranted to enter into particular speculations, and to speak with so much confidence on the subject as certain theorists have lately done. Sir John Herschel, who has paid more attention to this subject, and made more accurate observations on the nebulæ than almost any other individual, is far from being confident, and speaks with becoming hesitation and modesty in relation to this hypothesis. "If it be true," says he, "that a phosphorescent or self-luminous matter exists, disseminated through extensive regions of space in the manner of a cloud or fog—now assuming capricious shapes like actual clouds drifted by the wind, and now contracting itself like a cometic atmosphere around particular stars—what, we naturally ask, is the nature and destination of this nebulous matter? Is it absorbed by the stars in whose neighbourhood it is found to furnish, by its condensation, their supply of light and heat? or is it progressively concentrating itself by the effect of its own gravity into masses, and so laying the foundation of new sidereal systems or of insulated stars? *It is easier to pro-*

pound such questions than to offer any probable reply to them. Meanwhile, appeal to fact, by the method of constant and diligent observation, is open to us; and as the double stars have yielded to this style of questioning, and disclosed a series of relations of the most intelligible and interesting description, we may reasonably hope that the assiduous study of the nebulæ will ere long lead to some clearer understanding of their intimate nature."

On the whole, the nebulæ, whether resolvable or irresolvable, open to view an inexhaustible field of contemplation and wonder. By far the greater part of the nebulæ are undoubtedly clusters of stars, some of them, perhaps, containing as many millions as our Milky Way, and occupying a space in the tracts of immensity which imagination can never fathom; but a considerable proportion of these bodies evidently appear to be masses of self-luminous substances, without any indication of being formed into organized systems; and how enormous must be the extent of most of those masses, and how vast the regions of space which they fill! If every one of those bodies be only one half the size of the great nebula in Orion, what a prodigious mass of matter must they contain, and what immense space must hundreds and thousands of them occupy! To limited minds such as ours, such spaces appear as approximating to *infinity*, and all our previous ideas of the amplitude of planetary systems sink into something approaching to inanity. Whatever purposes these immense masses of matter may serve under the administration of Infinite Wisdom, certain it is *they exist not in vain*. They accomplish designs worthy of the plans of Divine Intelligence, and have doubtless a relation, in one respect or another, to the enjoyments of intelligent beings; but the full development of the plans and agencies of the Deity in this and in many other parts of the economy of the universe, must be considered as reserved for another and a future scene of existence.

SECTION VI.—*List of some of the Larger Nebulæ.*

For the sake of those who wish to inspect some of the nebulous bodies by means of telescopes, I have subjoined the following list from Messier's Catalogue, along with the more recent observations of Sir W. Herschel. The right ascensions and declinations are given in degrees and minutes, by

which the places of these bodies may be very nearly found on a celestial globe. If it be judged expedient to reduce the degrees and minutes of right ascension to *time*, it may be done by the following rules: Divide the number of degree by 15, the quotient is hours; and the remainder reduced to minutes, and divided by 15, gives the minutes, &c., of time: or, multiply the given number of degrees and minutes by 4, and divide the degrees in the product by 60, the quotient is hours, and the remainder minutes, &c. Thus, 320° 17′ is equal to 21 hours, 21 minutes, and 8 seconds of time.

In the following list, R.A. means right ascension; dec., declination; S., south; N., north; diam., diameter of the object, which is expressed in minutes of a degree.

1. R.A. 80° 0′ 33″; dec. N. 21° 45′ 27″; above the Bull's southern horn west of the star ζ: this consists of a whitish light, elongated like the flame of a taper: it exhibited a mottled nebulosity to Sir W. Herschel.
2. R.A. 320° 17′; dec. S. 1° 47′; diam. 4′; in the head of Aquarius, near the 24th star: it appears like the nucleus of a comet, surrounded with a large round nebula: Sir W. Herschel resolved it into stars.
3. R.A. 202° 51′ 19″; dec. N. 29° 32′ 57″; diam. 3′; between Arcturus and Cor Caroli: it is round, bright in the centre, and fades away gradually: it exhibited a mottled nebulosity to Sir W. Herschel.
4. R.A. 242° 16′ 26″; dec. S. 25° 55′ 40″; diam. 2½′; near *Antares*: a mass of stars.
5. R.A. 226° 39′; dec. N. 2° 57′; diam. 3′; near 6 Serpent: a round nebula, resolved into stars by Sir W. Herschel.
6. R.A. 261° 10′ 39″; dec. S. 32° 10′ 34″; diam. 15; between the bow of Sagittarius and the tail of Scorpio: a mass of small stars.
7. R.A. 264° 30′ 24″; dec. S. 34° 40′ 34″; diam. 30′: a mass of small stars near the preceding.
8. R.A. 267° 29′ 30″; dec. S. 24° 21′; diam. 30′; between the bow of Sagittarius and the right foot of Ophiuchus: an elongated mass of stars. Near this mass is the 9th of Sagittarius, which is encircled with a faint light.
9. R.A. 256° 20½′; dec. S. 18° 13′ 26″; diam. 3′; in the right leg of Ophiuchus: round and faint, but resolved by Sir W. Herschel into stars.

10. R.A. 251° 12′ 6″; dec. S. 30° 42″; diam. 4′; in the girdle near 30 Ophiuchus: a fine and round nebula, resolved into stars by Sir W. Herschel.

11. R.A. 279° 35′ 43″; dec. S. 6° 31′; diam. 4′; near K Antinous: a mass of many stars, mixed with a faint light.

12. R.A. 248° 43′; dec. S. 2° 30½′; diam. 3′; between the arm and left side of Ophiuchus: round and faint: near it is a star of the ninth magnitude; resolved into stars by Sir W. Herschel.

13. R.A. 248° 18′ 48″; dec. N. 36° 54′ 44″; diam. 6′; in the girdle of Hercules, between two stars of the eighth magnitude: round, and bright in the middle, resolved into stars by Sir W. Herschel.

14. R.A. 261° 18¼″; dec. S. 3° 5′ 45″; diam. 7′; in the drapery over the right arm of Ophiuchus: round and faint: near a star of the ninth magnitude: resolved into stars by Sir W. Herschel.

15. R.A. 319° 40′; dec. N. 10° 40′; diam. 3′; between the head of Pegasus and that of the Little Horse: round, and bright in the centre: resolved into stars by Sir W. Herschel.

16. R.A. 271° 15′; dec. N. 18° 51′ 44″; diam. 8′; near the Serpent's tail: a mass of small stars, mixed with a faint light: resolved by Sir W. Herschel.

17. R.A. 271° 45′ 48″; dec. S. 16° 14′ 44″; diam. 5′; north of the bow of Sagittarius: a train of faint light, with stars.

18. R.A. 271° 34′; dec. S. 17° 13′; diam. 5′; above the preceding: a mass of small stars, surrounded with nebulosity.

19. R.A. 252° 1′ 45″; dec. S. 25° 54′ 46″; diam. 3′; between Scorpio and the right foot of Ophiuchus: round, and resolved into stars by Sir W. Herschel.

20. R.A. 267° 4′ 5″; dec. S. 22° 59′ 10″; between the bow of Sagittarius and right foot of Ophiuchus: a mass of stars of the eighth and ninth magnitudes, surrounded with nebulosity.

21. R.A. 267° 31′ 35″; dec. S. 22° 31′ 25″; diam. 6′; near 11 Sagittarius: similar to the preceding.

22. R.A. 275° 28′ 39″; dec. S. 24° 6′ 11″; diam. 15′; near 25 Sagittarius: round, and resolved into stars by Sir W. Herschel.

23. R.A. 265° 42′ 50″; dec. S. 18° 45′ 55″; diam. 1° 30′; near 65 Ophiuchus: a mass of stars very near each other.
24. R.A. 270° 26′; dec. S. 18° 26′; near end of the bow of Sagittarius in the Milky Way: great nebulosity containing several stars; the light is divided into several parts.
25. R.A. 274° 25′; dec. S. 19° 5′; diam. 10′; near preceding, near 21 Sagittarius: a mass of small stars.
26. R.A. 278° 5′ 22″; dec. S. 9° 38′ 14″; diam. 2′; near n and o Antinous: a mass of small stars.
27. R.A. 297° 21′ 41″; dec. N. 22° 4′; diam. 4′; near 14 of the Fox: oval: it exhibited a mottled nebulosity to Sir W. Herschel.
28. R.A. 272° 29½′: dec. S. 24 57′; diam. 2′; a degree from λ Sagittarius: round, and resolved into stars by Sir W. Herschel.
29. R.A. 303° 54½′; dec. N. 37° 12′; below γ Cygni: a mass of seven or eight small stars.
30. R.A. 321° 46′; dec. S. 24° 19′; diam. 2′; near 41 Capricorn; round, and resolved into stars by Sir W. Herschel.
31. R.A. 7° 26½′; dec. N. 39° 9½′; diam. 40′; in Andromeda's girdle: it resembles two cones of light joined at their base, which is 15′ broad; resolved into stars by Sir W. Herschel.
32. R.A. 7° 27½′; dec. N. 38° 45½′; diam. 2′; below the preceding: round, without stars, and with a faint light.
33. R.A. 20° 9′; dec. N. 29° 32½′; diam. 15′; below the head of the North Fish and the great Triangle: its light is uniform and whitish: it exhibited a mottled nebulosity to Sir W. Herschel.
34. R.A. 36° 51½′; dec. N. 41° 39½′; diam. 15′; between Medusa's head and the left foot of Andromeda: a mass of small stars.
35. R.A. 88° 40′; dec. N. 24° 33½′; diam. 20′; near μ and η Castor: a mass of small stars near Castor's left foot.
36. R.A. 80° 11′ 42″; dec. N. 34° 8′ 6″; diam. 9′; near ϕ Bootes: a mass of small stars.
37. R.A. 84° 15′; dec. N. 32° 12′; near the preceding: a mass of small stars, with a nebulosity: resolved into stars by Sir W. Herschel.
38. R.A. 78° 10′; dec. N. 36° 12′; near σ Aurigæ: a square mass of stars.

39. R.A. 320° 57′; dec. N. 47° 25′; diam. 15′; near the Swan's tail: a mass of small stars.
40. R.A. 182° 45½′; dec. N. 59° 24′; diam. 1°; at the root of the Great Bear's tail: two stars very near each other.
41. R.A. 98° 58′; dec. S. 20° 33′; below Sirius: a mass of small stars.
42. R.A. 80° 59′ 40″: dec. S. 5° 34′ 6″; diam. 6′; between θ and c in Orion's sword: a beautiful nebula containing seven small stars.
43. R.A. 81° 3′; dec. S. 5° 26′ 37″; above the preceding: a star surrounded with nebulosity.
44. R.A. 126° 50½′; dec. S. 20° 31½′; between γ and δ Cancer: a mass of small stars.
45. R.A. 53° 27′ 4″; dec. N. 23° 22′ 41″; the Pleiades: a cluster of stars.
46. R.A. 112° 47′ 43″; dec. S. 14° 19′; between the Great Dog's head, and the hind feet of the Unicorn: a mass of stars with a little nebulosity.
47. R.A. 116° 4′; dec. S. 14° 50′; near the preceding: a mass of small stars.
48. R.A. 120° 36′; dec. S. 1° 16′ 42″; near the three stars at the root of Unicorn's tail: a mass of small stars.
49. R.A. 184° 26′ 58″; dec. N. 9° 16′ 9″; near ρ Virgo.
50. R.A. 102° 57½′; dec. S. 7° 57′ 42″; above θ Great Dog: a mass of small stars below Unicorn's right thigh.
51. R.A 200° 5′ 48″; dec. N. 48° 24′ 24″; below η Great Bear, near the ear of the Northern Greyhound: double: the two atmospheres, whose centres are 4′ 35″ distant, touch one another, and are bright in the middle; the one is fainter than the other: resolved into stars by Sir W. Herschel.
52. R.A. 348° 39½′; dec. N. 60′ 22″; below d Cassiopeia: a mass of stars mixed with a nebulosity, according to Sir W. Herschel: this cluster appears like a solid ball, consisting of small stars, quite compressed into one blaze of light, with a great number of loose ones surrounding it.
53. R.A. 195° 30½′; dec. N. 19° 22′ 44″; near 42 Berenice's hair: round, and resolved into stars by Sir W. Herschel.
54. R.A. 280° 13′; dec. S. 30° 44′; diam. 6′: in Sagittarius: faint, and bright in the centre.
55. R.A. 291° 30½′; dec. S. 31° 26½′; in Sagittarius: a white spot, resolved into stars by Sir W. Herschel.

56. R.A. 287°; dec. N. 29° 48′; near the Milky Way: faint, and resolved into stars by Sir W. Herschel.
57. R.A. 281° 20′; dec. N. 32° 46′; between γ and β Lyræ: round, and consisting of a mottled nebulosity.
58. R.A. 136° 37½′; dec. N. 13° 2′ 42″; in Virgo: very faint, without any star.
59. R.A. 187° 41′ 38″; dec. N. 12° 52½′; near the preceding: very faint, without any star.
60. R.A. 188° 7′; dec. N. 12° 46′; in Virgo: brighter than the two preceding.
61. R.A 182° 41′; dec. N. 5° 12′; in Virgo: very faint.
62. R.A. 251° 48½′; dec. S. 29° 45½′; in Scorpio: like a comet, with a brilliant centre surrounded with a faint light: resolved into stars by Sir W. Herschel.
63. R.A. 196° 5½′; dec. N. 43° 12½′; in the Canes Venatici: very faint.
64. R.A. 191° 27′ 38″; dec. N. 22° 52½′; in Berenice's hair; faint.
65. R.A. 166° 51′; dec. N. 14° 16′; in the Lion: faint, but resolved into stars by Sir W. Herschel.
66. R.A. 167° 11′ 39″; dec. N. 14° 12′ 21″; very near the preceding: very faint, but resolved into stars by Sir W. Herschel.
67. R.A. 129° 7′; dec. N. 12° 36′ 38″; below the northern claw of the Crab: a mass of stars with nebulosity. It is a cluster pretty much compressed, in which Sir. W. Herschel has observed 200 stars at once with a power of 157. (*See* p. 163.)
68. R.A. 186° 54½′; dec. S. 25° 30½′; diam. 2′; below the Crow: very faint.
69. R.A. 274° 11′ 46″; dec. S. 32° 31′ 45″; diam. 2′; below the left arm of Sagittarius: faint, like the nucleus of a small comet.
70. R.A. 277° 13′; dec. S. 32° 31′; diam. 2′; near the preceding, near four telescopic stars.
71. R.A. 295° 59′ 9″; dec. N. 18° 13″; diam. 3′ 30″; between γ and δ of the Arrow; very faint, and resolved into stars by Sir W. Herschel.
72. R.A. 310° 20′ 49″; dec. S. 13° 20′ 51″; diam. 2′; above the tail of Capricorn: faint, but resolved into stars by Sir W. Herschel.
73. R.A. 311° 43′; dec. S. 13° 28′ 40″; near the prece

ding: three or four small stars, containing a little nebulosity.

74. R.A. 21° 14′; dec. N. 14° 39′ 35″; near η in the string that connects the Fishes: very faint, but resolved into stars by Sir W. Herschel.

75. R.A. 298° 17′ 24″; dec. S. 22° 32′ 23″; between Sagittarius and the head of Capricorn: composed of small stars with nebulosity. The astronomer Mechain makes it only nebulous.

76. R.A. 22° 10′ 47″; dec. N. 50° 28′ 48″; diam. 2′; in Andromeda's right foot: composed of small stars with nebulosity, small and faint.

77. R.A. 37° 52½′; dec. S. 57′ 43″; in the Whale: a mass of stars containing nebulosity.

78. R.A. 83° 53⅓′; dec. S. 1′ 23″; diam. 3′; in Orion: a mass of stars with two bright nuclei, surrounded with a nebulosity.

79. R.A. 78° 49′; dec. S. 24° 43″; below the Hare: a fine nebula, bright in the centre, and a little diffused, resolved into a mottled nebulosity by Sir W. Herschel.

80. R.A. 241°; dec. S. 22° 25′; diam. 2′; between g and δ Scorpio: round, and bright in the centre, like a comet.

81. R.A. 144° 27′ 44″; dec. N. 70° 7′ 24″; near the ear of the Great Bear: a little oval, bright in the centre, and exhibiting a mottled nebulosity to Sir W. Herschel.

82. R.A. 144° 29′ 22″; dec. N. 70° 44′ 27″; near the preceding: faint and elongated, with a telescopic star at its extremity: it showed a mottled nebulosity to Sir W. Herschel.

83. R.A. 201° 8′; dec. S. 28° 42½′; near the head of the Centaur: very faint.

84. R.A. 183° 30⅓′; dec. N. 14° 7′; in Virgo: bright in the centre, and surrounded with nebulosity.

85. R.A. 183° 35′ 21″; dec. N. 19° 24½′; above and near Spica: very faint.

86. R.A. 183° 46′ 21″; dec. N. 14° 10′; in Virgo: the same as No. 84, and near it.

87. R.A. 184° 56′; dec. N. 13° 38′; in Virgo: as luminous as the preceding.

88. R.A. 185° 16′; dec. N. 15° 38′; in Virgo: very faint, and like No. 58.

89. R.A. 186° 9′ 36″; dec. N. 13° 46′ 49″; near No. 87: very faint.

90. R.A. 186° 27′; dec. N. 14° 23′; in Virgo: very faint.
91. R.A. 186° 37′; dec. N. 14° 57′; above the preceding fainter than the preceding.
92. R.A. 257° 38′; dec. N. 43° 22′; diam. 5′; between the knee and left leg of Hercules: a beautiful nebula, bright in the centre, and surrounded with great nebulosity: resolved into stars by Sir W. Herschel.
93. R.A. 113° 48′ 35″; dec. S. 23° 19′ 45″; diam. 8′: between the Great Dog and the Ship: a mass of small stars.
94. R.A. 190° 10′ 46″; dec. N. 42° 18′ 43″; diam. 2½′; above Cor Caroli: bright in the centre, with a diffused nebulosity.
95. R.A. 158° 3′ 5″; dec. N. 12° 50′ 21″; in the Lion, above *l*: very faint.
96. R.A. 158° 46½′; dec. N. 12° 58′; near the preceding: fainter than the preceding.
97. R.A. 165° 18′ 40″; dec. N. 56° 13½′; diam. 2′; near *β* Great Bear: very faint: another near it, and another near *γ*.
98. R.A. 180° 50′ 49″; dec. N. 16° 8′ 15″; above the north wing of Virgo: very faint.
99. R.A. 181° 55′ 19″; dec. N. 15° 37′ 12″; on the north wing of Virgo: brighter than the preceding: between two stars of the seventh and eighth magnitude.
100. R.A. 182° 59′ 19″; dec. N. 16° 59′ 21″; in the ear of corn of Virgo: brighter than No. 98.
101. R.A. 208° 52′; dec. N. 55° 24′ 25″; diam. 7′; between the left hand of Bootes and the tail of the Great Bear: very faint: discovered by Mechain: mottled nebulosity, according to Sir W. Herschel.
102. Between *o* Bootes and *ι* Draconis: very faint: discovered by Mechain.
103. Between *ε* and *δ* Cassiopeia: a mass of stars.

CHAPTER XIII.

ON THE ABERRATION OF THE STARS, AND ON THEIR PROPER MOTIONS.

THE aberration of the fixed stars is a small change of place in the heavens which they seem to undergo, and by which they appear to describe, in the course of a year, an ellipsis or circle, the greatest diameter of which is about forty seconds. This remarkable fact was discovered, near the middle of the last century, by the celebrated Dr. Bradley, formerly Regius Professor of Astronomy at Greenwich.

In Chapter IV., when describing the mode of finding the parallaxes of the fixed stars, I have given a brief detail of the circumstances which led to this discovery, and the observations from which the aberration of the stars was deduced. Before perusing the following illustrations of this subject, it may not be improper for the reader to reperuse what was there stated in reference to this point, particularly the illustration of this phenomenon given in the description of Fig. 7 (p. 62). It is there stated that Dr. Bradley and his friend Mr. Molyneux were very much perplexed at the result of their observations; since, instead of observing a motion indicating an annual parallax, they found a result directly opposite to what they expected Many theories and conjectures were proposed to solve the appearances, but nothing satisfactory was elicited, till one day, when Dr. Bradley was enjoying the amusement of sailing about on the Thames, he observed that every time the boat tacked, the direction of the wind, estimated by the direction of the vane, seemed to change. This immediately suggested to him the cause of the phenomenon which had so much perplexed him, and he ultimately found it to be an optical illusion, occasioned by a combination of the motion of light with the motion of his telescope while observing the polar stars; a discovery of no inconsiderable importance, and which will immortalize the name of this sagacious and indefatigable astronomer. He perceived that, if light is propagated in time, the apparent place of a fixed object will not be the same when

the eye is at rest, as when it is moving in any other direction than that of the line passing through the eye and the object; and that, when the eye is moving in different directions, the apparent place of the object will be different.

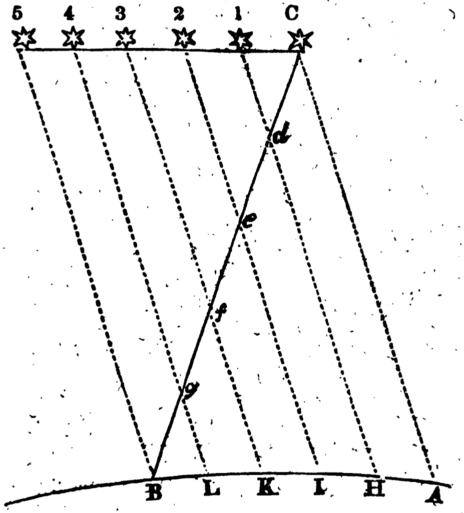
We see an object in consequence of the rays of light proceeding from it striking our eyes, and we see the place of the object *in the direction in which they proceed.* If light be in motion and the eye at rest, the object will appear in its real place, provided no refracting medium intervene; but if the eye be in motion, and this motion in a different direction from that of the rays of light, the object will not be seen in its true position. Let us suppose the earth in its circuit round the sun just arrived opposite to a fixed star, which sends off rays *perpendicularly* to the direction of the earth's motion. The eye of the spectator meets the ray, and, as he perceives not his own motion, he supposes the light to be moving in a different direction; as when we sail along a winding river, certain objects on the banks appear to pass by us in different directions. The eye misses the perpendicular ray, but meets an oblique one, and thence receives the impression of the light in the direction which results from this compound motion; namely, in the diagonal of a parallelogram, the sides of which represent the real motion of light. The spectator sees the star in its true place only when he is approaching it or receding from it in a straight line. When moving in any other direction, the star appears a little in advance of its true position; and these apparent changes in the situation of the heavenly bodies, occasioned by the annual motion of the earth, are distinguished by the *aberration of light.* They are common, to a certain extent, to all the celestial orbs, and are only more perceptible and striking in the case of the fixed stars. In consequence of this aberration during the revolution of the earth round the sun, the stars appear, according as they are situated in the plane of the ecliptic, or in its poles, or somewhere between them, in the first case, to deviate in a straight line to the right or left of their true place; in the second, to describe a circle, or something nearly approximating to it; and in the third, an ellipse about that point which observation determines to be their real situation.

This subject requires a little degree of attention in order to a clear understanding of it. Perhaps the following illustra-

tions may in some measure render it plain to the general reader.

Suppose *A B*, in the following figure, to represent a part of the orbit of the earth, and *C B* a ray of light descending from a star upon the earth's orbit, *A B*; if the eye be at rest at *B*, the object will appear in the direction *B C*; but if the eye be moving from *A* towards *B*, and light be propagated with a velocity that is to the velocity of the eye (or of the earth's motion) as *C B* to *B A*, that particle of it by which the object

Fig. 74.

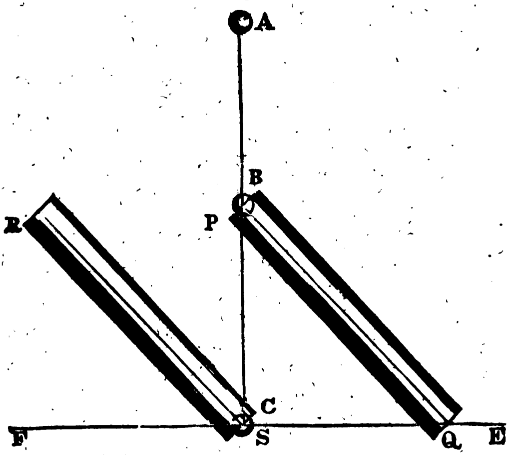


will be discerned when the eye comes to *B* will be at *C* when the eye is at *A*; the star, therefore, will appear in the direction *A C*; and as the earth moves through the equal parts of its orbit, *A H*, *H I*, *I K*, &c., the light coming from the star will move through the equal divisions *C d*, *d e*, *e f*, *f g*, *g B*, and the star will appear successively in the directions *H* 1, *I* 2, *K* 3, *L* 4, *B* 5, which are parallel to *A C*; so that when

the eye comes to B, the object will be seen in the direction B 5.

The following is an explanation of this phenomenon as given by Sir John Herschel. Suppose a shower of rain to fall perpendicularly in a dead calm; a person exposed to the shower, who should stand quite still and upright, would receive the drops on his hat, which would thus shelter him; but if he ran forward in any direction they would strike him in the face. The effect would be the same as if he remained still, and a wind should arise of the same velocity and drift them

Fig. 75.



against him. Suppose a ball to fall from a point A (fig. 75) above a horizontal line E F, and that at B were placed to receive it the open mouth of an inclined hollow tube P Q; if the tube were held immovable, the ball would strike on its lower side; but if the tube were carried forward in the direction E F with a velocity properly adjusted at every instant to that of the ball, *while preserving its inclination to the horizon*, so that when the ball, in its natural descent reached, C, the tube should have been carried into the position R S it is ev-

ment that the ball would, throughout its whole descent, be found in the axis of the tube; and a spectator, referring to the tube the motion of the ball, and carried along with the former unconscious of its motion, would fancy that the ball had been moving in the inclined direction *R S* of the tube's axis. Our eyes and telescopes are such tubes. The earth is moving through space with a velocity of nineteen miles per second in an elliptic path round the sun, and is therefore changing the direction of its motion at every instant. Light travels with a velocity of 192,000 miles per second, which, although much greater than that of the earth, is yet not *infinitely so.* Time is occupied by it in traversing any space, and in that time the earth describes a space which is to the former as 19 to 192,000, or as the tangent of 20″.5 to radius. Suppose, now, *A P S* to represent a ray of light from a star at *A*, and let the tube, *P Q*, be that of a telescope so inclined forward that the focus *formed* by its object-glass shall be *received* upon its cross wire, it is evident, from what has been said, that the inclination of the tube must be such as to to make *P S* : *S Q* : : velocity of light : velocity of the earth : : tangent 20½″ : 1; and therefore the angle *S P Q*, or *P S R*, by which the axis of the telescope must deviate from the true direction of the star, must be 20½″.

The aberration of the stars has also been illustrated by the direction in which a gunner points his gun at a bird on the wing. Instead of levelling it exactly at the bird, he directs it a little before the bird in the path of its flight, and so much the more in proportion as the flight of the bird is more rapid compared with that of the shot. It may likewise be explained by supposing a person to be walking in a shower of rain with a narrow tube in his hand, in which case it is evident that the tube must have a certain inclination, so that a drop of rain which enters at the top may fall freely through it without touching its sides; which inclination must be greater or less according to the velocity of the drops with respect to the tube.

From the discovery of the aberration of the stars, the following conclusions, among others, have been deduced: 1. That the small apparent motions which the fixed stars have about their real places arises from the proportion which the velocity of the earth's motion in its orbit bears to that of light. This proportion is found to be as 1 to 10,310; or, in other words, light moves with a velocity ten thousand three hundred and

ten times greater than that of the earth in its annual course round the sun.* 2. From this discovery it is proved that *the velocity of light is uniform* and the same, whether as emitted originally from the sun and stars, or reflected from the planets. The velocity of the earth in its orbit is about 68,000 miles an hour; consequently, the motion of light in the same time is 701,080,000, or a little more than seven hundred millions, which gives about eight minutes and eight seconds as the time it will take in passing from the sun to the earth.† This is about the same rate of the motion of light as first determined by Roemer from the eclipses of Jupiter's satellites; so that the two discoveries mutually harmonize and confirm each other, and prove to a demonstration the progressive motion of light, and that its rate of motion is the same whether as emanating from the sun, reflected from the satellites of Jupiter, or descending from the stars. 3. The aberration of light affects the apparent right ascensions and declinations of all the stars. Its effect on each particular star is to make it apparently describe a small ellipse in the heavens, having for its centre the point in which the star would be seen if the earth were at rest. Hence, in all very nice calculations and determinations of the positions of the stars, allowance must be made for the effects produced by aberration. 4. The aberration of light *affords a sensible and direct proof of the motion of the earth* in its orbit round the sun. If the earth were not in motion, no such effect as that of the aberration of the stars could take place. If the earth were at rest, rays from a star would pass along the axis of a telescope directed to it; but were it set in motion with its present velocity, these rays would strike against the side of the tube, and it would be necessary to incline the telescope a little in order to see the star. The angle contained between the axis of the telescope and a line

* This is the proportion of radius to the tangent of twenty seconds and a half, which is the greatest apparent displacement of the star caused by aberration, and the radius of the circle described by the star round its real place in the course of a year.

† This is found by multiplying 10.310= the number of times that the velocity of light exceeds that of the earth, by 68,000= the rate of the earth's motion in an hour; the product is 701.080.000 This product, divided by 60, gives the rate of motion in a minute= 11,684,666. Divide 95.000,000, the distance of the sun from the earth, by this last number, and the quotient will give eight minutes and nearly eight seconds as the time light should take in passing from the sun to the earth.

drawn to the true place of the star, is just what we call its *aberration*, which could not take place if the earth were not in motion. That the earth is a planetary body, moving through the depths of space along with the other planets of our system, can be proved by numerous considerations; but the fact of the aberration of the stars exhibits this motion to our senses as clearly as if from a fixed point in the firmament we actually beheld it pursuing its course through the ethereal regions; so that the planetary nature of our globe, and the truth of the Copernican system, are no longer to be considered as mere hypotheses, but as facts susceptible of the strictest demonstration.

On the Proper Motions of the Stars.

To the eye of a common observer, all the stars and constellations in the heavens appear to preserve the same relative distances from each other; and even astronomers, not more than two centuries ago, could perceive no separate motions or variations in the positions of these distant orbs. From this circumstance they were denominated *fixed stars*, to distinguish them from the *planets*, which were observed to shift their positions, and to move through different parts of the heavens. After the telescope was invented and applied to astronomical instruments, astronomers began to suspect that some of the stars had a slight degree of proper motion or change in their relative position; but it was a considerable time before such motions could be distinctly ascertained. These motions first began to be observed by Dr. Halley, and afterward by Lemonnier and Cassini, and were completely confirmed by Tobias Mayer, who compared the places of eighty stars as determined by Roemer with his own observations, and found that the greater part of them had a proper motion. He likewise suggested that the change of place he had observed among these stars might arise from a progressive motion of the sun towards one quarter of the heavens. La Lande deduced a similar opinion from the rotatory motion of the sun, by supposing that the same mechanical force which gave it a motion round its axis would also displace its centre, and give it a motion of translation in absolute space. Of the same opinion was Sir W. Herschel, and he attempted, by a comparison of the proper motions of all the stars that had been ascertained, to deter-

mine the point of the heavens towards which the motion of the sun was directed, which he supposed was that occupied by the star *Zeta* Herculis.

If the sun really have a motion in absolute space directed towards any particular quarter of the heavens, it is obvious that the stars in that quarter must appear to recede from each other, while those in the opposite region, which the sun is leaving behind, must seem gradually to approach, in the same manner as when we walk through a forest, the ranges of trees to which we advance are constantly widening in their apparent distance from each other, while the distance of those we leave behind is gradually contracting. It does not, however, appear, from the most recent observations, that the direction in which the sun or planetary system is moving is yet determined, although it is admitted that our system has a motion in space, and that the apparent proper motions of *some* of the stars *may be* the result of our being carried in a certain direction through absolute space by this motion. Such a motion, and even the direction of it, might be detected by such sidereal observations as those to which we allude, if we knew accurately the apparent proper motions of those bodies, and that they were independent of any *general motions* common to all the stars; but in the present stage of sidereal observation, it seems to be the general opinion of the most eminent astronomers, that no sufficient data are yet afforded for deducing definite conclusions on this subject.

The following table contains a few specimens of the annual proper motions of the stars in right ascension and declination, in seconds and decimals of a second, selected from the observations of Dr. Maskelyne. The first column contains the name of the star; the second its magnitude; the third its annual proper motion in right ascension; and the fourth its motion in declination.

In the following table, the sign + prefixed to the annual variation of right ascension, indicates that the variation is to be *added* to, and the sign — that it is to be *subtracted* from, the right ascension, to obtain the true place of the object at any given time.

Names of the Stars.	Magnitude.	Annual Motion in R. A.	Annual Motion in Dec.
		Seconds.	Seconds.
Capella	1	+0.21	+0.44 N.
Sirius	1	−0.42	+1.04 S.
Castor	1	−0.15	+0.44 S.
Procyon	1.2	−0.80	+0.95 S.
Pollux	2	−0.74	0.00
β Leonis	1.2	−0.57	+0.07 S.
β Virginis	3	+0.74	+0.24 S.
Arcturus	1	−1.26	+1.72 S.
Altair	1.2	+0.48	−0.54 N.
α Lyræ	1	+0.22	−0.27 N.
Antares	1	0.00	−0.26 N.

It is found that not only among single, but even among *double* stars, such motions exist. While revolving round each other in the manner formerly described, they are at the same time carried forward through space with a progressive motion common to both, and without sensibly altering their distances from each other. One of the most remarkable of these is the double star 61 Cygni, formerly described, whose annual parallax and distance Professor Bessel appears to have lately determined.* The two stars of which it is composed are nearly equal in apparent size, and they have remained constantly at the same distance of 15 seconds for at least fifty-seven years past, or since their positions began to be accurately observed. The annual proper motion of these two stars is found to be, according to Bessel, 5″.123; which is the greatest annual proper motion of any of the stars which has yet been discovered; consequently, during the period now mentioned, they must have shifted their local situation in the heavens by a space equal to 4 minutes 52 seconds; that is, a space equal to more than one seventh of the apparent diameter of the moon. Such a change of place in bodies so immensely distant as 62,000,000,000,000 of miles indicates a prodigious rapidity of motion. "The relative motion of these stars and the sun," says Bessel, "must be considerably more than sixteen† semi-diameters of the earth's orbit;" that is, 1,552,000,000 of miles. They must therefore move at the rate of four millions two hundred and fifty-two thousand miles a day, and one hundred and seventy-seven thousand miles

* *See* chap. iv., p. 65, &c. † About 16 1-3. *See* p. 68.

every hour; which is 68,000 miles an hour greater than the velocity of Mercury, which is the swiftest moving body in the planetary system. Here, then, we have a system of bodies of immense size moving with amazing velocity in different directions; for as these stars are doubtless suns, and, consequently, have a system of planets revolving round each, the planets must move round the sun to which they more immediately belong, and likewise round the other sun, or their common centre of gravity, and at the same time they are carried forward to some distant region with the velocity now stated.

Among single stars, that which is marked μ Cassiopeia, one of the smaller stars in that constellation, is remarked as having the greatest proper motion of any yet ascertained. The amount of its annual motion is estimated at 3¾ seconds, which in the course of a century will amount to 6 minutes 15 seconds, a space in the heavens equal to one fifth of the apparent diameter of the moon. If this star be reckoned at the same distance from the earth as the double star 61 Cygni, the velocity of its motion every day will be 3,112,000 miles; every hour, 130,000; and every minute, 2160. The annual proper motion of Arcturus, in declination, is 1″.72, which is nearly one half the motion of μ Cassiopeia; and a great many others are found by observation to be constantly progressing through the heavens by annual intervals of different degrees in extent, but generally smaller than those stated above. These changes of position in the stars cannot be perceived by the naked eye, and are consequently imperceptible to common observers; and even with the most accurate astronomical instruments some of them cannot be determined until after a lapse of years. Such motions give us reason to conclude that all the bodies in the universe are in perpetual motion, and many of them acted upon by separate forces, which carry them in different directions; and although some of these motions appear little more than just perceptible at the immense distance at which we are placed from them, yet it is probable that even the slowest motion of any of the stars is not less than at the rate of several thousands of miles every hour, indicating the operation of forces incomprehensible by the human mind.

CHAPTER XIV.

OF THE DESTINATION OF THE STARS; OR, THE DESIGNS THEY ARE INTENDED TO SUBSERVE IN THE SYSTEM OF THE UNIVERSE.

For many ages during the infancy of astronomy, the stars were considered chiefly as an appendage to the world in which we dwell. The crystalline sphere in which they were supposed to be fixed was regarded as only the canopy of man's terrestrial habitation, and the orbs with which it is diversified as so many brilliant spangles to adorn it, and to diffuse a few glimmering rays to cheer the darkness of the night. This celestial arch, in which the sun and moon are also placed, was supposed to revolve around us every twenty-four hours, producing an alternate succession of light and of darkness, while the earth, as the centre of the universe, was considered as remaining in a state of perpetual quiescence. Above the visible heavens, where the stars are placed, nothing was supposed to exist but the throne of the Almighty and the abodes of the blessed; and such are still the contracted views of the majority of the inhabitants of our globe, respecting that immense and glorious firmament with which we are surrounded.

It is true, indeed, that the stars, in a certain subordinate sense, were intended for the benefit of man; for we actually derive many advantages from their apparent motions and influence. They present to our view a scene of beauty and magnificence which enchants the eye and gratifies the imagination, and tends to raise the soul above grovelling pursuits and terrestrial vanities. They cheer the shades of midnight, and enable us to prosecute our journeys after the sun has left our hemisphere; without the influence of whose light our winter evenings would be surrounded in impenetrable darkness, and not an object around us could be distinguished. In the absence of the moon all would be dark, as was chaos before light was formed to illuminate creation. Were the light of the starry orbs extinguished, instead of the grand and beautiful aspect now presented from above the firmament would ap-

pear only like an immense blank or a boundless desert, where nothing would be seen to stimulate human inquiry or to display the attributes of the Creator. Those orbs are likewise of essential service in different departments of human life; they serve as guides to the traveller when journeying through vast and unfrequented deserts, and to the mariner when conducting his vessel from one country to another through the wide and pathless ocean. The Pole-star, on account of its apparently fixed position, has in every age been viewed with solicitous attention by the navigator: and before the invention of the compass it was his principal guide to direct his bark to the desired haven. In short, by means of the stars we have been enabled to determine the exact length of the day and of the year, the various subdivisions of time, the commencement and termination of the seasons, the circumference of the globe, the density of its materials, and the relative positions of places on every part of its surface; all which advantages it becomes man duly to appreciate, and with a grateful heart to adore the wisdom and goodness of Him "who made the sun to rule the day, and the moon and stars to rule the night," and who has rendered all his arrangements subservient to the happiness of his intelligent offspring.

But, although the stars are of essential benefit to the inhabitants of our globe, yet we ought not for a moment to imagine that this was the chief and ultimate end for which they were brought into existence. We know that they are bodies of immense size, the least of them many thousands of times larger than our globe. But such a number of magnificent globes were not necessary in order to shed a few glimmering rays upon the earth; since the creation of an additional moon would diffuse far more light over our world than that which descends to the earth from all the visible stars in the firmament. And we know that the Creator does nothing in vain. It is the characteristic of infinite wisdom to proportionate means to the end intended to be accomplished; but in this case there would be no proportion between the means and the end; between creating a thousand globes of light of incalculable magnitude, and shedding a few glimmering rays to alleviate the darkness of midnight; and therefore this cannot be supposed the chief end of their creation, without impeaching the wisdom and intelligence of Him "who stretched out the heavens by his understanding." Besides, whatever might be

said in reference to the stars visible to the unassisted eye, it is impossible for a moment to conceive that those thousands, and tens of thousands, and millions of stars, which are only visible through the most powerful telescopes, and whose light had never yet reached our globe, could have been created merely for the use of the inhabitants of this earth. Such a supposition must be for ever discarded by every one who would entertain an honourable and consistent idea of the operations of infinite wisdom.

What, then, it may be asked, is the chief and ultimate destination of those magnificent globes? We may answer in general terms, that it is a destination corresponding to the magnitude and grandeur, and the intrinsic splendour of those distant bodies. It is the characteristic of every wise artist and architect, that he elects the most proper means to accomplish the end intended, and proportionates every part of a machine or edifice to all the other parts, so as to produce a harmony and unity of design. A philosophical instrument-maker, for example, in constructing an orrery, does not make wheels of a hundred yards in diameter for carrying balls of less than an inch in diameter round a circle of only six feet in circumference; nor does a watchmaker employ two hundred wheels and pinions in the construction of a timepiece when less than a dozen may suffice; nor does an architect make the portico of an edifice five hundred times larger than the whole structure. Were any individual to act in this manner, he would at once be denounced as utterly destitute of wisdom, and viewed as a fool or a maniac. Now we are to consider the Almighty, in all his arrangements throughout the universe, as acting on the same general principle which directs a wise and intelligent artist in all his plans and operations; for wisdom is an essential attribute of the Divinity, and all his works, when minutely inspected, must necessarily display this perfection to intelligent minds. To suppose otherwise, to imagine for a moment either that he has not proportionated one part of the universe to another, or that the greater part of it was created for no use at all, would be the height of profanity and impiety, and would rob the eternal Majesty of Heaven of one of the most distinguishing attributes of his nature. Bearing this principle in mind, we are necessarily led to the conclusion—a conclusion as certain as any mathematical demonstration—namely, that the benefit of the inhabitants of our

globe was not the chief or ultimate design for which the stars were created, but that the Deity had a higher and more expansive design to accomplish in their formation. We do not pretend to fathom *all* the subordinate designs the Creator may have had in his view in the creation of the stars, or of any other object; but, as he has endowed us with rational faculties for the investigation of his works, it is evident that he intended we should be able to discover *some* of the main and leading designs which he intended to accomplish in the formation of the great bodies of the universe.

We therefore maintain, that one of the grand and leading designs of the creation of the stars was, that they should serve as *suns* to give light to other worlds and systems with which they are more immediately connected. This proposition I have all along taken for granted in the preceding pages, and shall now adduce a few arguments to elucidate and support it.

1. *They all shine by their own native light.* This is the peculiar characteristic of a sun in distinction from the planetary globes, which all shine with *reflected* light, derived from the luminous centre around which they revolve. The immense distance at which the nearest stars are placed from our globe is a clear proof that they shine, not with borrowed, but with inherent splendour; for reflected light from such a distance would be entirely dissipated ere it could reach our eyes. This likewise appears from actual observation, and from a comparison of the brilliancy of the fixed stars with that of the planets, in which there is found a striking difference. Mercury and Venus are the two planets which revolve in the immediate neighbourhood of the sun, and, consequently, derive from him a greater portion of light than any of the other planets; yet it is found that the lustre of the star *Sirius*, and even that of *Capella*, is much more brilliant than that of either Mercury or Venus; and it is demonstrably certain, that both these stars are situated beyond the orbit of Uranus; and therefore, if they derived their light from the sun, they behooved to be incomparably more obscure than any of the planets. The lustre and brilliancy which the fixed stars exhibit when viewed with telescopes of large apertures and powers is exceedingly striking. Sir W. Herschel seldom looked at the larger stars through his forty-feet telescope, because their blaze was injurious to his sight. At one time, after sweeping a portion of the heavens with that instrument, he tells us that "the appear-

ance of Sirius announced itself at a great distance like the dawn of the morning, and came on by degrees, increasing in brightness, till this brilliant star at last entered the field of the telescope with all the splendour of the rising sun, and forced me to take my eye from the beautiful sight." These and other circumstances clearly show that the stars are endued with native splendour, and are not dependant on any other luminaries for the brilliancy they display, and, consequently, are fitted to act as suns for the illumination of opaque globes with which they are more immediately connected.

2. *They are placed at an immense distance* from our earth and from one another, and, consequently, it is impossible that they could derive their lustre from our sun; for the sun, in his present situation, could afford them no more light than a single star transmits to our globe; and to some of the more distant stars his rays would be altogether invisible. And if the sun cannot be supposed to enlighten any of those orbs from the distance at which he is placed, there is no other body known to us from whence their light may be derived, if they do not shine with their own native splendour.

3. *They are bodies of immense magnitude.* We have already shown, both from mathematical considerations and popular illustrations, that the stars are unquestionably at a very great distance from our globe, a distance which is almost incomprehensible. (Chapter IV.) Their bulk must therefore be very great. If they were no larger than the globe on which we live, they would be altogether invisible, even although they shine with their own native light. Few of them can be considered as much less than our sun, and the greater number are in all probability much larger; they are therefore fitted, by their enormous size and their consequent attractive power, to be the centres of systems of planetary worlds, and to diffuse around them to an immense distance a splendid illumination. But it would be absurd to suppose that such a number of vast luminous globes, placed at such immense distances from each other, and from the earth, could have been created solely for the benefit of the inhabitants of our world; for it would argue a want of wisdom in not proportioning means to ends; since a single star of the one thousandth part of its present bulk, placed within a million of miles of the earth, would afford us far more light than all the stars put together.

4. Were we removed to the distance only of the nearest

stars, our sun would appear no larger than one of those twinkling orbs, and from some of them he would disappear altogether; at most, he would appear only as *one* of the small stars which deck the firmament, and probably one only of the fifth or sixth magnitude; consequently, all the planets of our system would entirely disappear. Even Jupiter and Saturn, though each of them is a thousand times larger than the earth, would be quite invisible, by reason of their comparative smallness and their shining only by *reflected* light. The system to which we belong cannot therefore be supposed to have any *immediate* connexion even with the nearest stars; and these stars must be considered as having appropriate purposes to fulfil in their own immediate sphere.

5. *The stars*, in point of number, size, and splendour, *constitute almost the whole universe*, at least so far as it has been unfolded to our view. The bodies which compose the planetary system contain a mass of solid matter about 2480 times larger than that of the earth, and the sun is about 500 times greater than the whole of them taken together. But this system, great as it appears in the eyes of mortals, is but as a diminutive ball, or even as a mere point, when compared with the myriads of stars which the firmament displays, and which the telescope has brought to view. These innumerable globes of light were created for *use*; to subserve important purposes in the plan of the Divine administration. They were not launched through the space of infinity at random, merely to display the energies of Omnipotence, and to light up the wilds of immensity with a useless splendour. Such a supposition would be derogatory to the attributes and character of the All-wise Creator, and would distort all the views we ought to entertain of a Being possessed of infinite perfection. Those immense bodies must therefore be conceived as intended chiefly to diffuse their light and splendour over worlds with which they are more immediately connected, and for the ultimate design of communicating happiness in various forms to the different orders of beings with which they may be replenished. What other subordinate ends they may accomplish in the grand scheme of the universe, besides the advantages we derive from them, is beyond our province to determine. It is not improbable, however, that every star or system, whether single, binary, or ternary, may have a subordinate end to serve to every other system, as forming

parts of one whole under the government of Infinite Wisdom. As we derive advantages from these orbs, distant as they are, and as they diversify the ceiling of our earthly habitation with a splendid decoration, so they will likewise adorn the firmament of other systems, and display to the view of their inhabitants both the energies of Omnipotent Power and the manifold wisdom of God.

6. *We have some direct indications that the fixed stars are in reality suns.* It forms no argument against the idea of the stars being the centres of systems, that we may have hitherto been unable to detect any of their revolving planets; for unless such planets be far beyond the magnitude of those belonging to our system, and unless their surfaces be fitted to reflect the rays of light with extraordinary brilliancy, we could not expect them to be visible at the remote distance at which we are placed, since the stars themselves appear only as shining points. But certain phenomena which have been observed, chiefly within the last century, give indication of the solar nature of the fixed stars. In the first place, there are phenomena which indicate that some of them at least, like our sun, have a rotation round their axes. In Chapter VII. we have given a brief view of the phenomena of *variable* stars. One of these, named *Algol*, is found *regularly* to pass through a change of brightness from the second to the fourth magnitude, and again to its original brightness, in two days and about twenty-one hours. The star β Lyræ passes through a periodic variation, from the third to the fifth magnitude, in six days and nine hours. A star in Hercules varies its lustre periodically, in the course of sixty days and six hours. A star in Sobieski's shield changes from the fifth to the seventh or eighth magnitude, and returns to its greatest brightness in a period of sixty-two days. These and many other stars give pretty evident indications of a rotation round their axes. Their periodic changes are *exact* and *regular*; and, in order to account for the phenomena, we have only to suppose that one of their hemispheres is either covered with large dark spots, or is encompassed with a medium which prevents it from emitting so much light to our eyes as the other, and that each hemisphere is presented to our view in alternate succession. Our sun, indeed, would not exhibit any sensible variation of lustre at the distance of the stars, notwithstanding some large spots on his surface; but we have no reason to

conclude that the stars, although they are all luminous bodies, are exactly alike in every part of their constitution, since variety appears to be a characteristic of all the arrangements in the universe. The darker hemisphere of the stars to which we allude may produce a change of illumination, which will form an agreeable vicissitude to the inhabitants of the worlds which roll around them, and which may produce an effect somewhat analogous to that which is produced by the alternate shining of a white and a yellow sun, as in the case of some of the double stars (see p. 126–130).

Again: there are stars whose periods of variable lustre are much longer than those now stated. Some of them pass through their periodic changes in 331 days, some in 494 days, and others not till after the lapse of eighteen years. Such changes, at least in some instances, may be accounted for by the intervention of opaque revolving bodies, or planets of a large size, passing directly between our eye and the stars, when revolving through that half of their orbits which lies next the earth. It is almost certain that either the one or the other of the circumstances now mentioned is the cause which produces the phenomena of variable stars, and in either case a strong presumption is afforded of the reality of other planetary systems. If *rotation* be the cause of the changes alluded to, the analogy between our sun and the stars is almost verified, for the most eminent philosophers have always considered that the rotation of an orb is necessarily connected both with motion in space and with the existence of revolving planets. If such changes arise from the interposition of opaque globes, as is highly probable in some of the cases we have stated, then we have direct evidence that the stars are in reality the centres of systems, and that their planets are constructed on a scale of magnificence far surpassing that of our solar system (see Chapter VII., p. 101–103). It is highly probable that both the causes to which we have now adverted operate in producing the phenomena of variable stars. Those whose periodic variations are the shortest may be produced by rotation, and those in which years are requisite to accomplish all the changes may arise from the intervention of very large opaque revolving bodies.

It has been surmised by some astronomers that certain very small stars which accompany larger ones probably shine by reflected light. Sir John Herschel, a few years ago, called

the attention of astronomical observers to this point. The stars to which he has requested particular attention are such as the following: ι Ursæ Majoris, γ Hydræ, κ Geminorum, α 2 Cancri, α 2 Capricorni, and several others. *Iota* Ursæ is a star of the third or fourth magnitude, in the fore foot of the Great Bear; right ascension 8h 46′ 54″, north declination 47° 51′ 20″. *Gamma* Hydræ is a star of the fourth magnitude, about thirty-five degrees southeast from Regulus, and about thirty-nine degrees west by south from Spica Virginis; right ascension 11h 15′ 57″, south declination 16° 42′. *Kappa* Geminorum is a star of the fourth magnitude, situated about three leagues and a half south of Pollux; right ascension 7h 33′ 38″, north declination 24° 49′. The star α 2 Capricorni is of the third magnitude, about twenty-two degrees south by east of Altair, and about two degrees and a half north of β Capricorni, &c. It is to the very small and pointlike stars which accompany these that the attention is to be directed; they are minute points of light, which can only be perceived by telescopes of considerable power. Some of these are suspected as shining with reflected light; and, if this point could be ascertained, it would form *a direct proof* of planets circulating around stars and enlightened by their beams. We have reason to hope, from the increase of astronomical observers, from the accuracy with which sidereal observations are now conducted, and from the improvements of which the telescope is still susceptible, that this interesting fact will ere long be determined by ocular demonstration; and, when such a discovery shall have been made, the telescope, which has already disclosed so many wonders, will then have performed one of its most sublime and mighty achievements.

In the mean time, we have no reason to entertain the least doubt that the stars are in reality *suns* and the distributors of light to other worlds, any more than we ought to doubt of the motion of the earth, because we have never, from a fixed point in the firmament, beheld it wheeling its rapid course through the ethereal spaces around the sun. Since the stars cannot, with the least show of reason, be supposed to have been created chiefly for the use of our globe, it is as certain as moral demonstration can make it, that they were principally intended to fulfil a higher and nobler purpose, and that this purpose has a respect to the accommodation and happiness of intelligent existence, either in the stars themselves or in worlds which

revolve around them; for the Creator and Governor of the universe must be considered, in all his arrangements, as acting in perfect consistency with those perfections of his nature with which he is eternally and essentially invested. But to suppose the innumerable host of stars to be only so many vast insulated globes, hung up to irradiate the void spaces of infinitude, would be repugnant to all the conceptions which reason and revelation lead us to form of a Being of infinite perfection.

If, then, the fixed stars are the centres of light and influence to surrounding worlds, how immense must that empire be over which the moral government of the Almighty extends! how expansive the range, and how diversified the order of planetary systems! how numerous, beyond calculation, the worlds which incessantly roll throughout the immensity of space! What countless legions of intellectual beings of every rank and capacity must crowd the boundless dominions of the King eternal, immortal, and invisible! and how glorious and incomprehensible must He be whose word caused this vast fabric to start into existence, and who superintends every moment the immensity of beings with which it is replenished! In attempting to grasp such scenes the human mind is bewildered and overwhelmed, and can only exclaim, "GREAT AND MARVELLOUS ARE THY WORKS, LORD GOD ALMIGHTY!"

"Seest thou those orbs that numerous roll above?
Those lamps that nightly greet thy visual powers
Are each a bright capacious sun like ours.
The telescopic tube will still descry
Myriads behind that 'scape the naked eye,
And farther on a new discovery trace
Through the deep regions of encompassed space.
If each bright star so many suns are found,
With planetary systems circled round,
What vast infinitude of worlds may grace,
What beings people the stupendous space?
Whatever race possess the ethereal plain,
What orbs they people, or what ranks maintain!
Though the deep secret Heaven conceal below,
One truth of universal scope we know:
Our nobler part, the same ethereal mind,
Relates our earth to all their reasoning kind,
One Deity, one sole creating cause,
Our active cares and joint devotion draws."

CHAPTER XV.

ON UNKNOWN CELESTIAL BODIES—ON METEORIC PHENOMENA —AND ON SHOOTING STARS.

We are not to imagine that we have yet discovered the greater part of the bodies which exist in those spaces whose range lies within the reach of our telescopes. All the discoveries which have hitherto been made in the heavens have been owing to the *light* emitted by very distant orbs having been concentrated on the eye by the magnifying and space-penetrating power of the telescope; but it is not improbable that there are numerous bodies within the circuit of the visible heavens which send forth no rays of light susceptible of being refracted or reflected to the eye by our finest instruments. Some of the largest bodies in the universe may either be opaque globes, or so slightly illuminated that no traces of their existence can ever be perceived from the region we now occupy. The greater part, if not the whole, of the orbs which have been descried in the firmament, with the exception of the planets and comets of our system, are globes which shine with their own inherent lustre, without which their existence would have been to us for ever unknown. We are not warranted to call in question the existence of any class of bodies merely because our limited organs of perception and our situation in the universe prevent us from perceiving them. We have never yet beheld the planets which doubtless circulate around other suns, although there can be no question that such bodies really exist; and there may be opaque globes of a size incomparably larger than either planets or suns, which may serve as the centres of certain systems, or for some other important purposes to us unknown; for all that we have yet explored of the distant regions of creation is but the mere outskirts of that boundless empire which stretches out on every hand towards infinity. It is not unreasonable to believe that the number of magnificent bodies imperceptible to our organs of vision may far exceed all that we have hitherto discovered either by the naked eye or the telescope, even within the compass of that region which lies open to human inspection.

It has been remarked by La Place, that "a luminous star of the same density as the earth, and whose diameter should be two hundred and fifty times larger than that of the sun, would not, in consequence of its attraction, allow any of its rays to arrive at us." "A star which, without being of this magnitude, should yet considerably surpass the sun, would perceptibly weaken the velocity of its light, and thus augment the extent of its aberration." It is therefore *possible* that the largest *luminous* bodies in the universe, if their internal structure be composed of dense materials, would be invisible to us, in consequence of their great attractive power preventing their light from reaching the system to which we belong. In Chapter XII. I have given a brief view of the ideas entertained by Lambert respecting the arrangement of the universe into distinct systems of stars, which have a more immediate connexion with one another in consequence of the law of mutual gravitation, and whose views have been partly confirmed by the discoveries of Herschel. This illustrious mathematician and astronomer endeavours to prove, by an induction of facts and reasonings, that, in order to the stability of those systems, it is necessary, on the principles of universal gravitation, that there be a large central body around which all the individuals which compose the system revolve. There is no necessity that such a central body should possess original or underived light. The fixed stars do not stand in need of it; and as for itself, if it require illumination, it will receive it from the suns that are more immediately adjacent. As to the *magnitude* of such a centre, Lambert estimates that the central body of the system to which we belong must have a diameter at least equal to the whole circumference of the orbit of Saturn. "The magnitude of those bodies," he says, "ought not to alarm us; for, in the first place, we have nothing to do with their bulk, but with their density or quantity of matter by which the law of gravitation is regulated. We have no idea of the density of matter that is not porous; perhaps gold, the most dense of terrestrial substances, would be found a mere sponge compared with such a central body. Besides, nothing is great or small in immensity; and since on the wing of light we can traverse the vast regions of the heavens, matter and volumes ought no longer to excite our astonishment. Beginning with the satellites, even suns are bodies of the first magnitude; the centres of the fixed

stars, of the fourth; those of groups of systems, of the fifth, and so of the rest."

Lambert supposes that, since such bodies must be of an enormous bulk, and illuminated besides by one or more fixed stars, it might be possible to perceive the one which belongs to our own system, either in whole or in part, with the help of the telescope; that its apparent diameter may be very considerable; that, however weak its reflected light, it may not be enfeebled tc such a degree as to be rendered imperceptible; that, being enlightened by one or more suns, it ought to present phases analogous to those of the moon; that such a central body ought to extend its influence even to the extremities of its system, and, consequently, ought to appear under a sensible diameter, or at least be visible by the telescope; and that, as the attractive force of a body decreases as the square of the sine of its apparent semi-diameter, so this apparent semi-diameter cannot be invisible in any place to which its attractive force and its sphere of activity extend. Without sanctioning all the opinions which this ingenious mathematician has thrown out on this point, we may admit that the subject is worthy of special attention, and might be kept in view when we are exploring the heavens with our best telescopes. What if some of the planetary nebulæ be bodies of a nature similar to those to which we have now alluded?

If opaque globes of a prodigious size exist throughout the regions of the firmament, as there is reason to believe, they would afford us a clew for unravelling certain phenomena which have hitherto remained in some degree inexplicable. Stars have appeared all at once, and, after having shone for a year or more with a brilliant light, have gradually disappeared. Certain stars are found to pass through regular variations of lustre, and for a certain period entirely disappear; but, after a lapse of a certain number of months or days, reappear and resume their former brightness. On the supposition that opaque bodies exist nearly in the direction of such stars, some of these phenomena would admit of an easy explanation. Their appearing and disappearing might be nothing more than an occultation or an eclipse, caused by the interposition of the opaque globe between our eye and the star. This would, indeed, suppose *motion* to exist either in the opaque body, or in the star, or in the eye of the observer; and perhaps the annual motion of the earth, or the motion of the sun in absolute

space, might contribute, in a certain degree, to produce the effect. Motion of some kind or other must necessarily be supposed, in order to account for the phenomena of variable stars, whatever hypothesis we may adopt for their explanation; but, as nothing decisive can be stated on this subject, in the mean time I shall proceed to the consideration of some meteoric phenomena which are now supposed to have a connexion with certain moving bodies in the heavens.

Meteoric Phenomena and Shooting Stars.

In my volume entitled "Celestial Scenery," when describing the small planets Vesta, Juno, Ceres, and Pallas, I have given a detail of certain facts respecting the fall of large masses of solid matter from the higher regions of the atmosphere, usually denominated *meteoric stones*, which, there is every reason to believe, descend from regions at a considerable distance, and even beyond the sphere of the moon. Such phenomena seem to indicate the probability that certain opaque bodies of different dimensions are revolving through space in certain regions within the limits of our system. "Nor is this," says Mrs. Somerville, "an unwarranted presumption; many such do come within the sphere of the earth's attraction, are ignited by the velocity with which they pass through the atmosphere, and are precipitated with great violence upon the earth. The fall of meteoric stones is much more frequent than is generally believed. Hardly a year passes without some instances occurring; and if it be considered that only a small part of the earth is inhabited, it may be presumed that numbers fall in the ocean, or on the uninhabited part of the land, unseen by man. They are sometimes of great magnitude; the volume of several has exceeded that of a body of seventy miles in diameter. One which passed within twenty-five miles of us was estimated to weigh about 600,000 tons, and to move with a velocity of about twenty miles in a second; a fragment of it alone reached the earth. The obliquity of the descent of meteorites, the peculiar substances they are composed of, and the explosion accompanying their fall, show that they are foreign to our system."

But, without resuming the consideration of this particular phenomenon, there is another which of late years has excited

a considerable degree of attention, and which may proceed from a cause somewhat similar, to which I shall chiefly direct the attention of the reader; namely, the phenomenon of *shooting or falling stars.* This phenomenon, though most frequently observed in tropical regions, is common in all parts of the earth, and has been seen in almost every season of the year. A shooting star seems to burst from a clear sky, and to dart across the heavens with a long train of light, which in a few seconds leaves no trace behind. Dr. Burney, of Gosport, for several years kept a record of such of these bodies as came under his own observation, and found that in the year 1819 there were 121, and in 1820 about 131; but a much greater number than these would doubtless be perceived could we detect all that make their appearance in the sky, the greater proportion, in all probability, being visible only during the hours usually allotted to sleep. Various opinions have been entertained respecting the cause of these appearances. Beccaria was of opinion that they were occasioned by electricity, and brought forward the following facts as corroborative of his hypothesis: About an hour after sunset, he and some friends that were with him observed a falling star directing its course directly towards them, and apparently growing larger and larger; but just before it reached them it disappeared. On vanishing, their faces, hands, and clothes, with the earth and all the neighbouring objects, became suddenly illuminated with a diffused and lambent light. During their surprise at this appearance, a servant informed them that he had seen a light shine suddenly in the garden, and especially upon the streams that he had been throwing to water it; when, sending up an electrical kite into the atmosphere, he likewise observed a quantity of electric matter about the kite, which assumed the appearance of a falling star. Whatever be the cause of shooting stars, it is pretty evident that they have their origin at a very considerable elevation above the earth. Brydone informs us that, from the top of Mount Etna, he noticed some of these meteors, "which still appeared to be as much elevated above us as when seen from the plain; so that in all probability those bodies move in regions much beyond the bounds which some philosophers have assigned to our atmosphere."

The most striking and remarkable form in which shooting stars have appeared is that of "meteoric showers," when thousands of those bodies have appeared to sweep along at

once, and in continued succession for several hours, so that almost the whole visible canopy of the sky seemed to be in a blaze. As this phenomenon has recently excited considerable attention among philosophers, and as it is now generally considered as connected with some moving bodies in the heavens, I shall, in the first place, give a detail of some of the more remarkable circumstances with which it has been attended, as described by those who were eyewitnessess of the scene. One of the most remarkable displays of the phenomenon to which we allude is that which was seen on the evening of the 12th and the morning of the 13th of November, 1833, in the United States of America. The following account of it is abridged from the *New-York Commercial Advertiser* of November 13, 1833:

"The sky was remarkably clear on the night of this remarkable phenomenon. Some time before twelve o'clock, the meteors so frequently seen on summer evenings, called *shooting stars*, were observed to fall with unusual frequency and splendour. They continued from that hour to flash athwart the skies more and more, until they were eclipsed by the glories of the rising sun this morning. From four to six they were most numerous and refulgent. Within the scope that the eye could contain, more than twenty could be seen at a time shooting (save upward) in every direction. Not a cloud obscured the broad expanse, and millions of meteors sped their way across it on every point of the compass. Were it possible to enumerate them in the swiftness of their arrowy haste, we might venture to say that for the space of two hours, intervening between four and six, more than a thousand per minute might have been counted. Their coruscations were bright, gleamy, and incessant, and they fell thick as the flakes in the early snows of December. In one instance we distinctly heard the explosion of a meteor that shot across to the northwest, leaving a broad and luminous track; and witnessed another which left a path of light that was clearly discernible for more than ten minutes after the ball, if such it be, had exploded. Its length was gradually shortened, widening in the centre, and apparently consisted of separate and distinct globules of light, drawing around a common centre, glimmering less and less vividly until they finally faded in the distance. Compared with the splendour of this celestial exhibition, the most brilliant rockets and fireworks of art bore less relation

than the twinkling of the most tiny star to the broad glare of the sun. The whole heavens seemed in motion, and never before has it fallen to our lot to observe a phenomenon so magnificent and sublime."

Various similar accounts of the same phenomena were given in the *Philadelphia*, *Hartford*, *Boston*, and other newspapers of the same date, of which the following are extracts:

"From a point in the heavens, about fifteen degrees southeasterly from our zenith, the meteors darted to the horizon in every point of the compass. Their paths were described in curve lines similar to those of the circles of longitude on an artificial globe. They were generally short in their course, resembling much an interrupted line, thus —— —— ——. They ceased to appear when within ten degrees of the horizon. I did not see a single meteor pass the meteoric pole I have described, nor one pass in a horizontal direction. Several of them afforded as much light as faint lightning. One in the northeast was heard to explode with a sound like that of the rush of the distant sky-rocket. Millions of these meteors must have been darted in this shower. The singularity of this meteoric shower consisted in the countless number of the celestial rockets, and more especially in their constant uniform divergence from near the zenith."

The following was an account sent by Professor Thomson, of Nashville, to Professor Olmsted, of New-Haven, of the meteors which appeared November 13, 1833, as seen in the state of Mississippi: "About an hour before daylight I was called to see the falling meteors; it was the most sublime and brilliant sight I had ever witnessed. The largest of the falling bodies appeared about the size of Jupiter or Venus when brightest. The sky presented the appearance of a shower of stars, which many thought were real stars and omens of dreadful events. I noticed the appearance of a *radiating point*, which I conceived to be the vanishing point of straight lines as seen in perspective. *This point appeared to be stationary.* The meteors fell to the earth at an angle of about seventy-five degrees with the horizon, moving from the east towards the west." The following is from a writer in the *Boston Christian Register*: "My first attention was to determine the centre or point from which the meteors started, which, from the place where I stood (lat. 42° 45′ N.), appeared in the Lion's heart, near Regulus. There is one

thing that I have not seen noticed by any that have written, and which could not have been noticed by me had I not kept my eye on the centre or point from whence the meteors all shot forth for a considerable time, and that was an appearance of a star less at first than the stars of the constellation by which it was surrounded, but it would increase until it was much larger than the stars, and then totally disappear from ten to fifteen minutes, and then appear again; but the meteors shot forth in greater numbers in the interval between the appearances above mentioned."*

It is worthy of particular notice, that the point from which the meteors seemed to emanate was observed, by those who fixed its position among the stars, to be in the constellation Leo; and, according to their concurrent testimony, this *radiant point* was stationary among the stars during the whole period of observation—that is, did not move along with the earth in its diurnal revolution *eastward*, but accompanied the stars in their apparent progress *westward*, which proves the elevation of the meteors to be far beyond our atmosphere. The following cut represents the appearance of these meteors

Fig. 76.

* This astonishing exhibition covered a very considerable part of the earth's surface. It has been traced from the longitude of 61° in the Atlantic Ocean to 100° in Central Mexico, and from the North American lakes to the West Indies.

for several hours, as seen at Boston, New-York, Philadelphia, and other places in the eastern parts of the United States. It is copied from one of the American periodicals published about the time when those phenomena appeared.

Meteoric phenomena, nearly resembling what has been now described, have occurred at several former periods. One remarkable instance of what was called "showers of fire" occurred above eighty years ago in South America. At Quito, so many falling stars were seen above the volcano of Gayambo, that the inhabitants were led to imagine the mountain to be in flames. The people assembled in the plain of Exico, and a procession was about to set out in consequence from the convent of St. Francis, when they discovered the phenomenon to be occasioned by meteors which ran along the skies in all directions.

A more extensive and remarkable phenomenon of this kind occurred in the night of the 12th of November, 1779. Of this appearance, as it was seen at Cumana, an accurate account has been given by M. Humboldt and M. Bonpland. It occurred towards the morning, when thousand of meteors, eolides, fireballs, or falling stars, as they were variously denominated, succeeded each other during four hours. Their direction was from north to south. They rose in the horizon at east-northeast, followed the direction of the meridian, and fell towards the south. There was little wind, and this from the east. No trace of clouds was seen. There was not a space in the firmament equal in extent to three diameters of the moon which was not filled with burning stars. They were of different sizes; they left luminous traces of from five to ten degrees in length. The appearance of these traces continued seven or eight seconds. Many of the stars had a distinct nucleus as large as the apparent disk of Jupiter. The largest were from 1° to 1° 13′ in diameter. Their light was white, and they seemed to burst as by explosion. They were seen by all the inhabitants of Cumana, the oldest of whom asserted that the great earthquakes of 1766 were preceded by similar phenomena.

It is a circumstance worthy of particular notice, that meteoric showers have taken place chiefly on the 12th and 13th of November, and hence they are now distinguished by the name of the *November Meteors*. Captain Hammond gives the following account of shooting stars seen at Mocha, on the

X 2

Red Sea, November 13, 1832, the day and month on which they have most generally been seen: "From one o'clock A.M. till after daylight, there was a very unusual phenomenon in the heavens. It appeared like meteors bursting in every direction. The sky at the time was clear, the stars and moon bright, with streaks of light and thin white clouds interspersed in the sky. On landing in the morning I inquired of the Arabs if they had noticed the above. They said they had been observing it most of the night. I asked them if ever the like had appeared before. The oldest of them replied that it had not."

On the morning of the 12th of November, 1799, a remarkable phenomenon of this kind was seen by Mr. Ellicot, near Cape Florida, which he thus describes: "The phenomenon was grand and awful; the whole heavens appeared as if illuminated with sky-rockets, which disappeared only with the light of the sun after daybreak. The meteors, which at any one instant of time appeared as numerous as the stars, flew in all possible directions, except *from* the earth, *towards* which they all inclined more or less, and some of them descended perpendicularly over the vessel we were in, so that we were in constant dread of their falling on us." The same appearances were observed *on the same night* at Santa Fe, Cumana, Quito, and Peru, in South America, as far north as Labrador and Greenland, and as far east as Weimar in Germany; thus having been visible over an extent on the globe of 64° in latitude and 94° of longitude. Meteoric showers were also seen on the morning of the 13th of November, 1831, in the Ohio country, and along the coast of Spain.

Flights of shooting stars, more or less numerous, have been seen in different places, both in Europe and America, at the same period, namely, the 13th of November, in the years 1834, 1835, 1836, and 1837, so that they are now considered as a regular periodical phenomenon. In a letter I received in 1837 from Elijah H. Burrett, Esq., A.M., a scientific gentleman in the state of Connecticut, and a correspondent of Professor Olmsted, he has the following notice on the subject: "With respect to the shooting stars, I believe Professor Olmsted is now very strong in the belief that they are exactly *periodical* and *annual*. The recurrence of this singular phenomenon on the morning of the 13th of November, 1836, and very nearly at the same hour; the radiation of the meteors

from the same point of the heavens, differing only one half a degree (as did those of 1834), namely, 145° right ascension in the face of Leo, and all the attending phenomena being the same, though upon a scale less magnificent, settle the question as to its being a regular and annual phenomenon. According to his notion, the zodiacal light is an attribute of the same cause, or an emanation from the same radiant. Accordingly, my friend Dr. Olmsted was fortunate enough to see just so much of the zodiacal light last May as to enable him to identify it with the phenomena of November, 1834, except that it was in the other node."

One of the most remarkable circumstances attending this display in 1833 was, that the meteors all seemed to emanate from one and the same point, a little southeast of the zenith. Following the arch of the sky, they ran along with immense velocity, describing in some instances an arc of 30° or 40° in a few seconds. On an attentive inspection, it was seen that the meteors exhibited *three* distinct varieties; the *first* consisting of *phosphoric lines*, apparently described by a point; the *second* of large *fireballs*, that at intervals darted along the sky, leaving luminous trains, which occasionally remained in view for a number of minutes, and in some cases for half an hour or more; the *third* of undefined *luminous bodies*, which remained nearly stationary in the heavens for a considerable time. Those of the first variety were the most numerous, and resembled a shower of fiery snow driven with inconceivable velocity. The second kind appeared more like falling stars, a spectacle which was contemplated by certain beholders with great amazement and terror. They were sometimes of enormous size. One of them, seen in North Carolina, appeared larger than the full moon rising, and its light rendered even small objects visible. The same ball, or a similar one, seen at New-Haven, passed off in a northwest direction, and exploded a little northward of the star Capella, leaving a train of peculiar beauty. The line of direction was at first nearly straight, but it soon began to contract in length, to dilate in breadth, and to assume the figure of a serpent scrolling itself up, until it appeared like a luminous cloud of vapour floating gracefully in the air, where it remained in full view for several minutes. Of the third variety the following are examples: At Poland, State of Ohio, a luminous body was distinctly visible in the northeast for more than an hour. It was very

brilliant, in the form of a *pruning-hook*, and apparently twenty feet long and eighteen inches broad. It gradually settled towards the horizon until it disappeared. At Niagara Falls, a large luminous body, shaped like a *square table*, was seen near the zenith, remaining for some time almost stationary, emitting large streams of light.

The recurrence of this wonderful phenomenon at the same season of the year soon attracted the attention of the philosophers of Europe, and they resolved to watch more particularly the aspect of the nocturnal heavens in the month of November. The celebrated M. Arago made arrangements to procure simultaneous observations from the different parts of France, for the night between the 12th and 13th of November, 1836. The following is the substance of the report which was published of these observations. The places at which observations were made, and the number of meteors counted, were as under:

Paris, at the observatory	170
Dieppe, 100 miles northwest of Paris	36
Arras, 100 miles north of Paris	27
Strasburg, 250 miles east of Paris	86
Von Altemare, 260 miles southeast of Paris	75
Angon, 180 miles southwest of Paris	49
Rochefort, 260 miles south-southwest of Paris	23
Havre, 120 miles west of Paris	300

Besides these positive observations, information was received of similar phenomena having been observed at other places. In the neighbourhood of Tours, for example, the peasants declared they had seen a rain of fire during the night; and in the valley of the Rhone, near Culloy, three asteroids succeeded each other with such rapidity, that the people, seeing them through a fog, supposed them to be flashes of lightning, or a repetition of the brilliant aurora of the 18th of October. As in the great meteoric shower of 1833, so at this time, the greater part of the falling stars which were particularly observed seemed to issue from a point in the constellation of Leo. Of those noticed at Bercy, fifty-seven traversed lines which, if continued, would have ended in that constellation; and of eighty-five observed at Strasburg, fifty-seven had similar courses. M. Arago proposes an inquiry whether, from their number, this shower of falling stars may or may not be considered unusual; and he gives the following com-

parisons: At Paris, on the preceding night, none were seen during an hour; from three to five were seen in the same space of time on the night after the shower, and from two to three on the second night. On the preceding night, at Bercy, not one was seen in two hours. At Von Altemare, on the 6th of November, none were seen during two hours' watching; on the 7th, there were four in four hours; on the 8th, none in three hours; on the 9th, one in six hours; and on the 14th, two in six hours.

I have been somewhat particular in stating the more remarkable circumstances connected with this phenomenon, as there is every reason to believe that it is produced by an unknown celestial body at a considerable distance from the earth; and I shall now proceed to give a brief view of the opinions which certain philosophers entertain, and the deductions they have been led to make in reference to this subject.

In the "American Journal of Science" for April, 1834, Dr. Olmsted, professor of mathematics and natural philosophy in Yale College, New-Haven, has entered into an elaborate investigation of this subject, in a communication which occupies about forty-two pages. The whole of this paper is well worthy of the attentive perusal of the philosophic inquirer, but the limits to which I am necessarily confined in this chapter will permit me to state only the *general results* of the professor's investigations; all of which appear to be deduced from the phenomena with great acuteness and ingenuity of reasoning. These results are:

1. That the meteors of November 13th *had their origin beyond the limits of our atmosphere.* For the source of the meteors did not partake of the earth's motion, which was demonstrable from a variety of circumstances, some of which have been alluded to above.

2. That *the height of the place whence the meteors emanated,* above the surface of the earth, *was about* 2238 *miles.* This was ascertained from a comparison of different observations made in different places, and from trigonometrical calculations founded upon them.

3. *The meteors fell towards the earth, being attracted to it by the force of gravity.* It seemed unnecessary to assign any other cause, since gravity is adequate to produce the effect.

4. *They fell towards the earth in straight lines, and in directions which, within considerable distances, were parallel*

with each other. The courses are inferred to have been straight lines, because no others could have appeared to spectators in different situations to have described arcs of great circles.

5. *They entered the earth's atmosphere with a velocity equal to about four miles per second*, or more than ten times greater than the maximum velocity of a cannon ball, and about nineteen times that of sound. This was inferred from the laws of falling bodies.

6. *The meteors consisted of combustible matter, and took fire and were consumed in traversing the atmosphere.* They were seen glowing with intense light and heat, increasing in size and splendour as they approached the earth. They were seen extinguished in a manner in all respects resembling a combustible body like a sky-rocket; and in the case of the larger, a cloud of luminous vapour was seen as the product of combustion. That they took fire *in the atmosphere* is inferred from the fact that they were not luminous in their original situation in space, otherwise the body from which they emanated would have been visible.

7. *Some of the larger meteors must have been bodies of great size.* Some of them appeared larger than the full moon rising. Such a body seen at 110 miles distance behooved to have been one mile in diameter; at fifty-five miles, one half mile; at 22 miles, one fifth of a mile; at 5½ miles, one twentieth of a mile, or 264 feet.

8. *The meteors were constituted of light and transparent materials.* They were of light materials, otherwise their momentum would have been sufficient to enable them to make their way through the atmosphere to the surface of the earth. They were transparent bodies, otherwise we cannot conceive how they could have existed together in their original state without being visible by reflected light.

9. The next, and one of the principal subjects of inquiry, was, *What relations did the body which afforded the meteoric shower sustain to the earth?* Was it of the nature of a satellite that revolves round the earth as its centre of motion? Was it a collection of nebulous matter, which the earth encountered in its annual motion? or was it a comet, which chanced at this time to be pursuing its path along with the earth around their common centre of motion? It could not have been a satellite, because it remained so long stationary

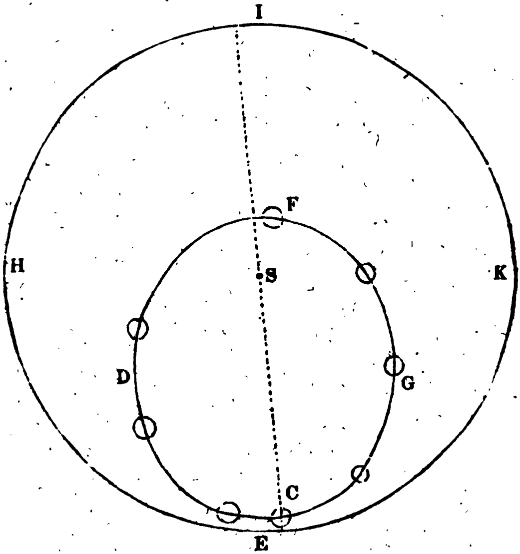
with respect to the earth; nor was it a *nebula*, either stationary or wandering lawless through space. Such a collection of matter could not remain *stationary* within the solar system; and had it been in motion in any other direction than that in which the earth was moving, it would soon have been separated from the earth, since, during the eight hours while the meteoric shower lasted, the earth moved in its orbit through the space of 540,000 miles. The conclusion to which Professor Olmsted arrives, after a due consideration of all circumstances, is the following:

That the meteors of November 13th consisted of portions of the extreme parts of a nebulous body, which revolves around the sun in an orbit interior to that of the earth, but little inclined to the plane of the ecliptic, having its aphelion near to the earth's path, and having a periodic time of 182 days nearly.

This conclusion, the professor thinks, will account for the following, among other circumstances: Why the phenomenon remained so long stationary with respect to the earth; why it was seen in that particular part of the heavens; and why it returns at stated periods, having appeared at Mocha, in Arabia, just one year preceding, and in a manner very similar to the present, as described by Humboldt and by Ellicot thirty-four years before. It will likewise account for an auroral light, resembling daybreak, which was seen in the east several hours before the dawn of day, and it is also supposed it may account for the different appearances of the *zodiacal light*. The professor is of opinion that the body alluded to is somewhat analogous to that of a comet. Fig. 77 represents the supposed orbit of this body in relation to that of the earth. *E H I K* represents the orbit of the earth; *S*, the position of the sun; and *C D F G*, the supposed orbit of the body which was the source of the meteoric phenomena. At the time these phenomena were seen, the body is supposed to have been at *C* when the earth was at *E*.

Arago appears to entertain an opinion on this subject not very different from that of Dr. Olmsted. He supposes that there may be myriads of bodies, composed probably of *nebulous* matter similar to the tails of comets, circulating round the sun in a zone or ring, that crosses the earth's orbit at that part where it is about the 12th November, and that some of them, drawn from their course by the earth's attraction, fall towards it, and taking fire when they enter the atmosphere, in consequence of

Fig. 77.



their prodigiously rapid motion, present the luminous phenomena of falling stars. The body or bodies from which these meteors proceed, he considers as unquestionably in rapid motion, performing a revolution round the sun in some plane different from that of the earth's orbit; and that the apparent course of the meteors will be compounded of this proper motion and of the earth's motion in its orbit at the time. It follows, that the point from which they seem to come will be that towards which the earth is moving at the time, namely, the constellation *Leo;* for the line or tangent of the earth's annual motion at the 13th and 14th November points exactly to that constellation.*

* A gentleman in South Carolina thus describes the effect of the phenomenon of 1833 upon his negroes: "I was suddenly awakened by the most distressing cries that ever fell on my ears. Shrieks of horror and cries

Thus it appears that celestial bodies are revolving around us of which we formerly had no knowledge or conception. A new planetary system, within the limits of the old, is beginning to be revealed to us, the number of the bodies belonging to which may be much greater than we are yet aware of, and their particular properties and motions may at no distant period be detected and explained. This is one proof, among others, that bodies of a considerable size may exist in the heavens, and be prosecuting their courses in various directions, though they have never been detected by our telescopes. The subject is peculiarly interesting to philosophers and astronomers. The facts which have already been observed afford a *sensible proof* of the attractive power of the earth over bodies at a distance in the heavens; and it is to be hoped that the future observations and investigations of scientific men, in relation to such phenomena, will threw some farther light on the nature and properties of bodies which have hitherto been involved in darkness and mystery. What the destination of such bodies may be, or the ends they serve in the economy of nature, we are as yet entirely ignorant of. It appears pretty evident that they are bodies of no great density, otherwise their effect on the earth might have been more terrific and disastrous. Had their quantity of matter been considerable, when accompanied with so prodigious a velocity as they evidently had, their momentum would have been such as to dash them with violence upon the earth, where the most appalling effects might have been produced, in the demolition of human habitations, and the destruction of thousands of their inhabitants. But it does not appear that any of them made their way through the atmosphere *to the surface of the earth*, which was doubtless owing to the comparatively light materials of which they were composed. This circumstance,

of mercy I could hear from most of the negroes on three plantations, amounting in all to about six or eight hundred. While earnestly listening for the cause, I heard a faint voice near the door calling my name. I arose, and, taking my sword, stood at the door. At this moment I heard the same voice still beseeching me to rise, and saying, 'Oh, my God! the world is on fire!' I then opened the door, and it is difficult to say which excited me most; the awfulness of the scene, or the distressed cries of the negroes. Upward of one hundred lay prostrate on the ground; some speechless, and some uttering the bitterest cries, but most with their hands raised, imploring God to save the world and them. The scene was truly awful; for never did rain fall much thicker than the meteors fell towards the earth; east, west, north, and south, it was the same!"

along with many others, evidently shows that we may be surrounded with numerous bodies and substances impalpable to the organs of vision, any one of which might be sufficient to deprive us of our comforts, and even prove destructive to our existence, were it not under the direction and control of Infinite Wisdom and Benevolence.

CHAPTER XVI.

ARGUMENTS ILLUSTRATIVE OF THE DOCTRINE OF A PLURALITY OF WORLDS.

Having in the preceding pages exhibited a condensed view of the principal facts in relation to the Sidereal Heavens, I shall now inquire into some of the designs which the Almighty Creator appears to have had in view in replenishing his universe with such an immense number and variety of magnificent orbs. In Chapter IX. of "Celestial Scenery," I entered on a consideration of this subject, and illustrated at some length a few leading arguments, which tend to prove that *matter* was created chiefly in subservience to *mind*, and that the main object of the creation of the planets, as proved from all the decorations and special arrangements connected with them, was to afford habitations for numerous orders of sensitive and intellectual beings. Without resuming the consideration of any of the arguments there stated, I shall in this chapter offer a few additional arguments corroborative of the same position, which, taken in connexion with the former, will, I trust, amount to a moral demonstration that all the great globes in the universe are in some respect or another connected with intelligent existence.

I. The first class of arguments I shall illustrate is the following: That *the doctrine of a plurality of worlds is more worthy of the perfections of the Infinite Creator, and gives us a more glorious and magnificent idea of his character and operations than to suppose his benevolent regards confined to the globe on which we dwell.*

1. The doctrine of a plurality of worlds is more accordant with the idea of the *infinity* of the Divine Mind than any other

position. It is admitted by all rational theists and theologians that the Divine nature fills the immensity of space, and we consequently adore the Creator as an infinite and incomprehensible being. But we can have no ideas approximating to what infinity really is, unless by the prospects opened to us of the indefinite extension of material existence. Beyond the limits we may assign to the material world, our ideas, if we have any ideas at all, run into confusion and approximate to inanity. It does not comport with the idea of a Being of infinite perfection that his works should be confined to one point of infinite space, or that one comparatively small race of intelligent beings should be the sole object of the moral government of Him whose presence fills the regions of immensity. It is more corresponding to the conceptions we ought to form of such a Being that the immensity of his works should correspond, in some degree, to the immensity of his nature; and, so far as our knowledge and observation extend, this is in reality the case. Beyond the range of natural vision the telescope enables us to descry numerous objects of amazing magnitude; and, in proportion to the excellence of the instrument and the powers applied, objects still more remote in the spaces of immensity are unfolded to our view, leaving us no room to doubt that countless globes and masses of matter lie concealed in the still remoter regions of infinity, far beyond the utmost stretch of mortal vision. But huge masses of matter, however numerous and widely extended, if devoid of intelligent beings, could never comport with the idea of happiness being coextensive with the range of the Creator's dominions. Such an idea would completely obscure the lustre of all his other attributes, and prevent them from being known and appreciated wherever his Omnipotence is displayed. To consider creation, therefore, in all its departments, as extending throughout regions of space illimitable to mortal view, and filled with intelligent existence, is nothing more than what comports with the idea of Him who inhabiteth immensity, and whose perfections are boundless and past finding out.

3. The idea of the indefinite extension of the universe and a plurality of worlds is most accordant with the *eternity* of the Divine Mind. When we go back in imagination to ages and centuries of duration more numerous than the drops of ocean or the sands on the seashore, we find the Deity existing in all the plenitude of his incommunicable attributes; for "He

inhabiteth eternity" as well as immensity. There is nothing repugnant either to reason or revelation to suppose that, innumerable ages before our globe was arranged into its present state, many regions of infinite space were replenished with material existence; for the Scriptures nowhere assert that the *materials* out of which our globe was arranged were brought from nothing into existence *at the period* when Moses commences his narrative of the processes which preceded the formation of man. Nor have we any reason to believe that the operations of Creating Power have ceased since the structure of our world was completed, but have some evidences of the contrary; for example, in the case of *new stars* which have made their appearance at different periods since the time of the Mosaic creation, and even within the limits of the last century. It does not appear corresponding to the idea of an *Eternal* Being, whose existence can never terminate, and whose perfections are the same at all periods of duration, that everything should stand still in the universe, and that nothing new should arise into existence during the lapse of infinite duration, which would, in effect, be the case if the work of creation were absolutely finished, or if man were the principal intelligence connected with the material system.

Whether the happiness of the Divinity may be increased by the contemplation of his purposes and plans being brought into effect, we cannot positively declare; though it does not appear contrary to reason or the dictates of Scripture to suppose that even the felicity of the Deity may, in a certain limited and modified sense, be susceptible of augmentation.* But, whatever opinion may be formed on this point, from the constitution of *finite* minds, and the principles and desires implanted in them, it appears necessary to *their* progressive enjoyment

* It is declared in Psalm cxlvii., 11: "The Lord taketh pleasure in them that fear him, in those that hope in his mercy;" and in relation to Messiah it is said, "Jehovah is well pleased for his righteousness' sake." In reference to the material works of creation it is said, Psalm civ., 31, "The glory of the Lord shall endure for ever; *the Lord shall* REJOICE *in all his works*." The expression, "The glory of the Lord," denotes the display of the Divine perfections made in the works of creation, as is evident from the subject of the psalm in which it occurs, which celebrates the power, wisdom, and providence of God in relation to the objects of the visible world. In reference to these objects it is said, "The Lord shall *rejoice*" in them, which seems to imply, speaking after the manner of men, a degree of pleasure or satisfaction in beholding his wise and benevolent plans and his eternal purposes brought into effect and fulfilling the ends intended.

that new scenes and manifestations of Divine perfection should be continually opening to their view; and if the universe be indefinitely extended, as it appears to be, and if new worlds are continually springing up under the creating hand of the Omnipotent, then we behold a prospect of progressive knowledge and enjoyment, suited to the desires and aspirations of intelligent minds, which can never terminate throughout all the future periods of eternity. It is, indeed, *absurd* to suppose that a Being without beginning and without end should have his attention solely or chiefly directed to one point of his universe and to one class of intelligences, "to whom," in point of number and of rank, "they are counted as nothing, and less than nothing, and vanity."

In respect to a Being, then, who fills the infinity of space with his presence, and who is possessed of eternal duration, it is nothing more than what is consistent with these attributes, and what we should naturally expect, that his empire should stretch over the regions of immensity, and that it should be filled with innumerable intelligences, capable of appreciating his power and goodness, and of paying a tribute of gratitude and adoration. The two attributes to which we have adverted could never be thoroughly displayed to finite minds, unless creation were extended through the illimitable tracks of space, and new creations gradually unfolding themselves to view. Were creation as limited as many suppose, were it confined chiefly to the world in which we dwell and the beings connected with it, we might, in the course of a few ages, be said in some measure to comprehend the Creator; having explored all the displays he has made of his power, wisdom, and goodness; for we know nothing more of the Deity than the *manifestations* he has made of himself in his works and his moral dispensations. Everything in relation to man and his habitation might be known after the investigations of a very limited number of ages, and nothing farther would remain to stimulate the exercise of the rational faculties throughout all the succeeding periods of infinite duration. But we may rest assured that the Divine Being is absolutely incomprehensible, and that no created intelligence will ever be able to sound the depth of his perfections, or to trace the full extent of his operations.

3. It is more accordant with the *wisdom* of the Deity that the universe should be inhabited by intelligent minds, than

that it should remain in a state of perpetual desolation and solitude.

Could it be proved that the planets of the solar system, and all the other magnificent globes which are dispersed throughout creation, are only rude masses of matter, without life and intelligence, it would confound all our ideas of the intelligence of the Divine mind. Wisdom is universally acknowledged to be one of the eternal and essential attributes of the Divinity. But how could the glory of this attribute be traced from the contemplation of a mass of mere inanimate matter, however vast and splendid in its general aspect, when no end or design of its creation is perceived? Where should we be enabled to perceive the nice adaptation of means to ends? the harmonious operation of principles and causes producing grand and beneficent effects? the accomplishment of glorious and useful designs by admirable arrangements? We could only behold a vast and stupendous assemblage of means *without an end*; or, at least, without an end corresponding to their magnitude and grandeur. We should behold merely a display of boundless and uncontrollable *power* acting at random, and producing no effect which could excite the love and adoration of holy intelligences. For what could they behold to excite such emotions, although they were permitted to make the tour of the universe? Scenes of emptiness and desolation, of silence and solitude, where no sound is heard, where no animated being enlivens the boundless prospect, where no interchange of sentiment or affection can take place, and where no praises from adoring worshippers ever ascend to the Ruler of the skies. A rational being, traversing scenes of this description, would feel as little enjoyment as a bewildered traveller amid storms and tempests, wandering over a vast howling wilderness, where human feet had never trod, and where the sweet accents of the human voice are never heard to cheer the surrounding solitude.

But when we view the magnificent globes which are scattered throughout immensity as replenished with numerous orders of intelligent beings, we behold an *end* worthy of the grandeur of the means which have been employed, worthy of the Omnipotent Power which has been exerted, and corresponding to the perfections of him who is "the only wise God," who is "wonderful in counsel and excellent in working." We behold a display of Divine wisdom and munificence which is

calculated to arrest the attention and draw forth the admiration of all rational beings, and to excite the most ardent desires of beholding the distant scenes of the universe more completely unfolded; a display calculated to gratify intelligences of the highest order and of the most capacious powers, to excite them to the most sublime investigations, and to inspire them with emotions of love, reverence, and adoration of Him who created all worlds, and for whose pleasure they are and were created.

4. The idea of the universe being replenished with sensitive and intellectual existence is accordant with every rational view we can take of the *goodness* or *benevolence* of the Deity.

The goodness of God is that attribute of his nature by which he delights to communicate happiness to all the ranks of his sentient and intelligent offspring. Like every other attribute of the Divine mind, it is strictly boundless or infinite, coextensive with the eternal greatness of that mind, and commensurate with infinite knowledge, wisdom, and omnipotence The benevolence of the Deity may be said to constitute his whole moral character, and to reflect a radiance on all his other perfections. To his *love* of happiness, as it now exists among every order of his creatures, and to his *desire* of producing it in all his future arrangements, no possible limits can be affixed. Hence, in the sacred records, the Divine Being is summarily described by this perfection alone, "*God is love.*" It is not merely asserted that God is benevolent, but that he is *benevolence* itself. Benevolence is the essence of his being and character; a summary of everything that can render him amiable and adorable in the eyes of all his intelligent creatures. This benevolence is permanent and immutable, and must be *for ever active* in distributing blessings wherever percipient beings exist. As it consists in the love of happiness, and the desire of communicating it wherever there is scope for its exercise; as it is the boundless energy of the infinite Mind in unceasingly doing good, it must be displayed, in a greater or less degree, wherever matter exists, and wherever wisdom and omnipotence have been exerted throughout the universe. We know that it is incessantly displayed throughout all the departments of our terrestrial system, in the ample provision made for the wants of every species of animated existence, in "giving" the various tribes of men "rain from heaven and fruitful seasons, and filling their hearts with food and gladness;" and, in a wonderful diversity of

modes, distributing enjoyment among percipient beings. It is celebrated in the highest strains by the inspired writers as one of the most glorious and distinguishing characteristics of Jehovah. "The Lord is good to all; his tender mercies are *over all* his works." "He is merciful, and gracious, and *abundant* in goodness." "His bounty is great above the heavens," and "he exercises loving-kindness throughout the earth." "Oh give thanks to the Lord, for he is good, for his mercy endureth for ever."

But, however great and inexhaustible the source of happiness in the Divine mind, the *exercise* of goodness *necessarily supposes the existence of sensitive or rational beings*, towards whom benevolence may be displayed. Where no such beings are to be found, the attribute cannot be exercised or traced in its operation. Mountains and plains, rocks of marble and diamonds, or valleys adorned with all manner of precious stones, however rich and splendid, cannot feel the effects of Divine beneficence. If, therefore, the numerous globes throughout the universe were destitute of inhabitants, there would be no extensive display of this essential perfection of the Divine nature; and to those few intelligences who might be permitted to view the desolate wastes of the universe, or to receive information respecting them, it would appear as if the Divine goodness had either been exhausted or had ceased its operations, and been withdrawn from the scene of creation, as if "the Lord had forgotten to be gracious, and in anger shut up his tender mercies." We have reason, however, to believe, both from Scripture and from reason, that it is the great end of all the operations of Deity that a theatre may be prepared on which the emanations of his goodness may be communicated to innumerable orders of beings throughout his vast creation. There is no other conceivable end for which the fabric of universal nature was reared, than that it should serve as a scene of enjoyment to innumerable beings susceptible of feeling the effects of the Creator's bounty, and that therein they might behold a magnificent display of the grandeur of his eternal attributes; but if by far the greater part of creation were uninhabited, such an end would be frustrated. However expansive the scene of the universe may be, however numerous and magnificent the worlds and systems which exist within its boundless range, the glories of Omnipotence would remain for ever veiled and unknown, ex-

cept to a small race of beings who occupy only a point in the immensity of space, and who cannot be possibly acquainted with the ten thousandth part of the scenes which lie in the remoter spaces of creation.

If, therefore, we would not rob the Divinity of the most distinguishing attribute of his nature, we must admit that wherever creation extends, his goodness and beneficence are displayed, and, consequently, that intelligent beings of various orders must exist throughout all its amplitudes. Wherever power and wisdom are displayed, it ought to be considered as a necessary consequence that there also goodness is exercised, as the one is subsidiary to the other, and stands related as means to an end, or as cause to effect. It would be a most glaring inconsistency to suppose that the Divine benevolence is confined to one or two worlds or orders of beings, when millions of expansive systems diversify the fields of immensity; more especially when we consider that the goodness of the Deity is of so *communicative* a nature that all the interval between a polypus and a man is filled with thousands of species of animated beings, of every conceivable form, and structure, and capacity, in order that happiness of every degree may be diffused among every possible order of sentient existence. Every element of nature, every department of our terrestrial system, forms an appropriate abode for living beings. The air, the waters, and the earth teem with animated existence of every size and form, and in such vast multitudes as to exceed all human calculation; and if the displays of Divine goodness be thus exuberant in our sublunary world, it would be absurd in the highest degree to suppose for a moment that the millions of vast globes which roll in the distant regions of creation are void of inhabitants, since the communication of happiness appears to be one great end of all the operations of infinite wisdom and omnipotence.

Thus it appears that the doctrine of a plurality of worlds is not only accordant with every rational view we ought to entertain of the eternity and immensity, the wisdom and goodness, of the Divine Being, but that the opposite opinion would be repugnant to every consistent and scriptural view we can take of the character of the Supreme, and would obscure the glory of every divine perfection. This view, therefore, of the universe, considered as replenished with innumerable intelligences, is calculated *to exhibit a more glorious and magnifi-*

cent idea of the character and operations of the Deity than to suppose his benevolent regards confined to the globe on which we dwell. Instead of having only one comparatively small world and race of beings under his sway, we here contemplate him the supreme ruler of ten thousand times ten thousands of mighty worlds, and conducting them all with unerring skill in their vast career. We behold him exercising his moral administration over a vast *universe of minds*, more numerous than the faculties of men or of angelic beings are adequate to compute, supporting and directing all the amazing powers of thought, wisdom, intelligence, affection, and moral action, throughout every part of his eternal empire, displaying the depths of his wisdom and intelligence, the rectitude of his character, and the grandour of his omnipotence to countless orders of intellectual existence, presenting before them prospects of magnificence and grandeur boundless as immensity, distributing among them all the riches of his beneficence, and inspiring them with the hope that the grandeur of his kingdom and the glory of his perfections will continue to be displayed with increasing splendour throughout all the periods of an endless duration. Such a Being is calculated to draw forth the highest degree of love and admiration from all his intelligent offspring, to inspire them with glowing ardour in his service, and to excite them to incessant adoration; whereas, did the universe consist merely of a boundless mass of matter without animation, thought, or intelligence, a veil of darkness and mystery would be thrown over all the perfections and purposes of the Divinity; creation would appear a vast, mysterious, and inexplicable system; and no hope would ever be entertained of tracing the designs for which it was brought into existence.

II. Another general argument for a plurality of worlds, and for an extensive population of the universe, may be founded on the following proposition, that, *wherever any one perfection of Deity is exerted, there also* ALL *his attributes are in operation*, and must be displayed, in a greater or less degree, to certain orders of intelligences. This is a most important consideration, which ought to be taken into account in all our views of the Divine character, and in all our investigations of the Divine administration; a consideration which is too frequently overlooked in the views and reasonings both of philosophers and theologians.

The Divine Being is ONE undivided essence; he is not compounded of *separable* parts or qualities, insulated from each other. We ought not, therefore, to conceive of his attributes as so many independent powers or properties, any one of which may be exerted without the concurrence or cooperation of the other. From the limited views we too frequently take of the divinity, and from the imperfection of our present faculties, we are apt to fall into this mistake; but since all the perfections we attribute to the Eternal Mind are attributes of one indivisible and uncompounded being, we ought never to imagine that *power* in any instance operates without *goodness*, or *wisdom* without *rectitude*, or that it can ever happen that any one of those perfections can be displayed without the harmonious operation of the whole. In whatever region of the universe, therefore, God is seen to operate by his power, we may rest assured that there also he displays himself in the plenitude of all his other perfections; that intelligence, wisdom, benevolence, veracity, and rectitude follow in the train of omnipotence, displaying in undivided lustre and harmony the glories of his character. It is GOD, invested with all his eternal and immutable, his natural and moral attributes, and not any single perfection, that acts, arranges, and governs throughout the whole amplitude of creation; and as such, his moral grandeur, as well as the physical effects of his power, must be displayed in every department of the material universe. From the influence of habit, and in consequence of the limited faculties of our nature, we are accustomed to say, that in one object *power* is displayed, and in another that *wisdom* is manifested; because that in the one the attribute of power appears to us more prominent, and in the other wisdom is more strikingly apparent. A lofty range of mountains, rearing their summits above the clouds, and stretching along for several hundreds of miles, strikes the mind with an idea of *power* in Him who formed them; but the fine mechanism, accomplishing certain useful purposes in the body of an emmet or a gnat, or the delicate construction of the eye of a dragon-fly, arrests our attention more particularly as an evidence of *wisdom*, although in each of these cases both power and wisdom are displayed. In no act or operation whatever of the Divine Being can it be said, that in that act he is *only* wise, or only powerful, or only benevolent; for in every operation, and in every part of his procedure, he acts in the *plenitude* of

all his essential attributes, although the full display of all his perfections may not, in every instance, be open to our inspection.

If, then, the positions now stated be admitted (and I see not how they can be called in question), it necessarily follows that all the vast globes dispersed throughout the universe are either inhabited, or contribute, as our sun does, to the comfort and enjoyment of percipient existence; for if wisdom and goodness uniformly, and of necessity, accompany the agency of power, and if these attributes can be exercised only in relation to sentient or intelligent beings, such beings must exist wherever such perfections are exercised. To suppose the contrary would involve a palpable absurdity, and present a distorted and inconsistent view of the adorable character of Jehovah.

In our survey of the sidereal heavens and the remoter provinces of the Divine empire, we behold little more than an overwhelming display of almighty power. Our remoteness from those magnificent scenes prevents us from tracing the minute contrivances of Divine Wisdom in relation to any particular system, or the displays of Divine Beneficence towards its inhabitants. But our incapacity of perceiving the effects of wisdom and goodness forms no argument against the actual exercise of these perfections. If it be admitted that infinite wisdom and benevolence are the necessary accompaniments of almighty power, we may rest assured that those perfections are in full and constant exercise wherever creating power has been exerted, although, from our present situation in the universe, their operation be concealed from our view. In every instance where Omnipotence has put forth its energies, it may be considered as a stage or theatre on which the Divine wisdom and benevolence may be displayed. And as wisdom and goodness can only have a reference to percipient and intelligent beings, wherever those perfections are exercised, such beings must necessarily be conceived to exist; otherwise we in effect destroy the *simplicity* of the Divine nature, we divide the Divine essence into so many independent attributes, and virtually declare that in the work of creation the Deity does *not* act in the full exercise of his indivisible and eternal perfections.

The above considerations, if duly weighed and understood, appear to me to imbody an argument for the doctrine of an

indefinite plurality of worlds which may be considered as amounting to a moral demonstration.

III. There is *an absurdity involved in the contrary supposition*, namely, that the distant regions of creation are devoid of inhabitants.

1. There are two modes of reasoning which have been employed to prove the truth of a proposition; the *direct* method, by bringing forward arguments, or following out a train of reasoning bearing expressly on the position to be supported; or the *indirect* method, by showing the absurdity of maintaining the opposite position. Mathematicians term this latter species of reasoning the *reductio ad absurdum*, and sometimes employ it instead of the direct method, by showing that the contrary of the position laid down is impossible, or involves an absurdity; and this method of proof is considered as valid and as strictly demonstrative as the other; for the opposite of truth must be falsehood. If, therefore, any proposition, whether mathematical or moral, can be shown to involve an absurdity, or to be inconsistent with a well-known and acknowledged truth, or directly contrary to it, we may safely conclude that such a proposition must be *false*.

To feel the force of such an argument in the present case, let us suppose for a moment that the planetary and stellar orbs are destitute of inhabitants. What would be the consequences? All those vast bodies must then be considered as regions of eternal silence, solitude, and desolation. The sun illuminates the surfaces of such huge globes as Jupiter and Saturn, but there are no visual organs to perceive the lustre he throws around, no percipient beings to feel the influence of his heat and other benign agencies. Time is measured with exquisite precision by days, and months, and years, but all to no purpose; for no rational beings enjoy the advantage of such measures of the lapse of time, and the Deity—to whom "one day is as a thousand years, and a thousand years as one day"—stands in no need of such movements to mark the periods of duration. Day and night, spring and summer, succeed each other, but they have no relation to the wants or enjoyments of sensitive or intellectual natures. The melody of the groves, the bleating of flocks, the lowing of herds, the harmonious accents of human voices, or the music of angelic choirs, never for a moment disturb the profound and awful silence which for ever prevails; not a single murmur meets the

ear, unless howling winds, amid dreary deserts and rugged rocks, should render the scene still more hideous and doleful. Some of those mighty globes are encircled with splendid rings and a retinue of moons, which adorn the canopy of the sky, and present a scene of grandeur far more diversified and sublime than human eyes have yet beheld; but no intelligent agents exist in those regions to admire and enjoy the wondrous spectacle and to adore the Creator. In short, all is one wide scene of dreariness, desolation, horror, and silence, which would fill a spectator from this world with terror and dismay.

Were an inhabitant of earth to be transported to Jupiter or Saturn, he might behold resplendent scenes in the canopy of the firmament; but how great would be his disappointment to find nothing but boundless deserts and desolate wastes, without one sentient being to cheer the horrors of the scene, and not a rational intelligence to communicate a single sentiment or to join him in the contemplation of the objects above and around him; and were he to range, throughout an indefinite lapse of ages, from one globe to another, and from one corner of the universe to another, and find the same gloomy solitudes and desolations, he could find no stimulus to excite him to admiration or rapture, or to elevate his soul in adoration of the Creator. Even the most resplendent scenes, adorned with all the riches and beauties which the most lively imagination can depict; mountains of diamonds, and plains diversified with all the beauties of the vegetable creation, could impart no real pleasure while unenlivened with the principle of animation and the energies of *mind*. What a gloomy and horrible picture would such a scene present of the frame of universal nature, and what a veil of darkness and mystery would it throw over the perfections of the Eternal! for it is the scenes connected with life, animation, mental activity, moral sentiment, glowing affection, social intercourse, and the mutual sympathies of intellectual beings, that can alone inspire the soul with rapturous emotions, throw a charm over any part of creation, and exhibit the Almighty Creator as amiable and adorable. It is chiefly from the relation in which the material world stands to sensitive and intellectual existence that its beauty and order are recognised and admired by contemplative minds, and that the wisdom and beneficence of the Deity are traced in all their minute and multifarious bearings. In our world, as it now stands, the arrangement of mountains

and vales, the various properties of the watery element, and its transmutation into vapours, clouds, and dew, the admirable mechanism of the atmosphere, the fertility of the earth, and the beautiful colouring which is spread over the face of nature—which are productive of so many beneficial effects, and so evidently display the wisdom of Deity—would all appear as so many means without an end, as contrivances *without use,* if the earth were destitute of inhabitants. And if all the other departments of creation were likewise devoid of animation and intelligence, scarcely a trace would be left throughout boundless space of the wisdom and benevolence of the Eternal Mind.

2. In the next place, such a position as that which I am now opposing would be inconsistent with that principle of *variety* which appears so conspicuous throughout the whole range of the Divine operations, and with *that progressive expansion of intellectual views* which appears necessary to the perpetual enjoyment of immortal beings.

In order to permanent enjoyment, it is necessary, from the very constitution of the mind, that one scene of happiness should succeed another; that the soul should look forward to the future, to something *new,* or more grand and expansive than it has yet beheld or enjoyed. It can never rest in present objects and attainments, but is always on the wing for something higher and more exquisite than it has yet grasped or enjoyed. What is the reason, in most cases, why *imprisonment* produces so doleful an effect upon the mind, but because its views and its actions are confined to a narrow circle? And if in such a situation newspapers, books, paper, pens and ink, be withheld, so as still farther to circumscribe the mental view, its want of enjoyment and its misery are still more increased. Why would a literary man feel unhappiness had he no access to books, journals, and the periodicals of the day, nor any other means of information respecting passing events, but because he would thus be confined to his present range of view, and prevented from enlarging it? And why should the man who devours the periodical journals to-day, feel as craving desires to-morrow to pursue similar records of intelligence, to mark the progress of passing events, but from the same vehement desire to expand his present intellectual views? Were such desires to remain ungratified, and the prospect of farther information entirely shut up, a certain degree of misery

would necessarily be felt by every rational mind. In another world, something similar would happen in the case of all intellectual beings, were no new scenes and prospects ever unfolded to view

Divines have generally admitted that the eternal world, in the case of the righteous, will be a state of perpetual and uninterrupted enjoyment. Such enjoyment, however, could never be realized, unless new scenes and objects, worthy of the admiration of exalted intelligences, were progressively displayed. But the contemplation of rude masses of matter, however vast in point of size and extent, and however magnificent in point of splendour, were they entirely unconnected with mind and moral action, would produce no high degree of enjoyment to beings possessed of capacious powers of intellect; for in such objects they could trace no evidences of skill or design, nor would they perceive any overflowings of Divine goodness to inspire them with gratitude and praise. We are warranted from Revelation to expect that in the future world the *knowledge* of good men will be indefinitely increased, in respect to their more enlarged conceptions of the Divine Being, and of his works and ways; that, among other subjects, they shall become more acquainted with the distant regions of creation, the destination of those great globes which we now behold at an impassable distance, the history of their inhabitants, the various stages of improvement through which they have passed, the most remarkable events which have happened among them since their creation, the relations which the different worlds bear to each other, the various orders of intellectual beings, and their distinctive characteristics and endowments, with many other particulars, which would afford an ample field of investigation and contemplation which could scarcely ever be exhausted, and a source of progressive and permanent delight. But all such prospects of knowledge and enjoyment would be for ever shut out, were the universe a collection of mere matter unconnected with mind or intelligence, and the distant view of an immortal existence would present little else than a scene of monotony or a boundless blank.

In the future world, although the circumstances in which the mind will exist will be different from its present local associations, yet its faculties, desires, and affections will not be *essentially* changed. It will continue the same identical be-

ing, only transported to another region, and connected with other objects and associations. It will have the same or similar aspirations after happiness, the same desires after new objects and discoveries, and the expansion of its intellectual views, and the same delight in beholding one scene of creating grandeur after another unfolding itself to view, as it feels, in a certain degree, in the present state. Such desires after progressive improvement in knowledge and happiness are implanted by the Creator, and form an essential part of the constitution of the human soul, and therefore can never be eradicated so long as it is sustained in existence. But it is evident, from what has been already stated, that such desires could never be gratified, and that its expectations of higher degrees of intellectual expansion and enjoyment would be frustrated, were the scene of Omnipotence nothing more than an indefinite extension of matter without life or intelligence; for in such a case there would be little scope for the exercise and expansion of its powers throughout an immortal existence.

8. The supposition that matter throughout the universe is not connected with mind would present a distorted view of the character of the Almighty, and throw a veil over the most glorious perfections of his nature. It would virtually deprive the Creator of the attribute of *wisdom*; since no display of it would be perceived in the most magnificent works of his hands. It would, in effect, rob him of his *goodness*; since, throughout the mightiest and most extensive portion of his works, no enjoyment is communicated to beings endowed with either sensitive or rational natures, which are alone capable of being recipients of his bounty; consequently, no tribute of gratitude and thanksgiving would be offered, and no praises or adorations would ascend to the throne of the "King eternal, immortal, and invisible," from the greatest portion of his boundless dominions. It would prevent us from beholding any extensive display of the *rectitude* of his character and the equity of his government in the moral administration of the universe. Now wisdom, goodness, and rectitude can only be exercised in reference to intelligent natures, and cannot possibly be displayed where such beings have no existence.

The denial, therefore, of the position, that the great universe is peopled with inhabitants, would lead us to contemplate a Being whose power has brought into existence a magnificent assemblage of means without an end; who has prepared

glorious habitations fitted for the enjoyment of rational natures, but has never peopled them; who is the alone source of happiness, and yet refuses to communicate of his goodness where there is full scope for its exercise; and who is the Supreme Lawgiver and the spring of moral order, and yet affords no display of his moral attributes throughout the immensity of his works: for this earth, and all the beings that have ever been connected with it, are but as a drop to the ocean compared with the immensity of the material universe. Can it therefore be a theatre of sufficient expansion for the display of the character and attributes of that Being who has existed from eternity past, and will exist to eternity to come, and whose presence fills the amplitudes of boundless space?

If, then, such absurd consequences necessarily follow from maintaining the position that there is no plurality of worlds, *that position cannot possibly be true*. It undermines truths of the first importance, which lie at the foundation of all consistent views of the character of the Deity, and which are acknowledged to be such by all rational theists and Christian divines. And, since what is directly opposed to truth must be error, and *vice versâ*, it follows that the doctrine we are supporting must be considered as susceptible of moral demonstration; for it may be laid down as an axiom, that it is essential to the character of Deity that he act consistently in all parts of his dominions, that he display in every instance *all his perfections* in harmony, and that, wherever his omnipotence has been exerted, there likewise he must display his wisdom, benevolence, and rectitude. Whatever opinion, therefore, directly tends to undermine or oppose such views of the Divine character and perfections, must be absolutely untenable, and the opposite opinion must be indisputably true.

In my work on "Celestial Scenery" I entered on the consideration of several arguments which tend to prove the doctrine of a plurality of worlds, and that the planets of the solar system in particular are the abodes of intellectual beings. This position was illustrated at some length from the following considerations: that there are bodies in the planetary system of such *magnitudes* as to afford ample scope for myriads of inhabitants; that there is *a general similarity* among all the bodies of the system, which affords a presumptive evidence that they are intended to subserve the same ultimate designs; that, connected with the planets, there are certain *special arrangements* which indicate their adaptation to the enjoyment

of sensitive and intellectual beings; that the scenery of the heavens, *as viewed from the surfaces of the larger planets and their satellites*, forms a presumptive proof of the same position; and that the fact *that every part of nature in our world is destined to the support of animated beings* affords a powerful argument in support of this doctrine. These arguments and considerations, when viewed in all their bearings, and in connexion with the wisdom and goodness of the Divine Being, might be considered, without any farther discussions, as quite sufficient to substantiate the position, that the planets and satellites of our system, as well as other departments of the universe, are the abodes of sensitive and intelligent beings.

In the preceding pages I have offered a few additional considerations bearing on the same point, which I trust will tend to corroborate the arguments and reasonings formerly adduced. I have shown that the doctrine of a plurality of worlds is more worthy of the perfections of the infinite Creator, and gives us a more magnificent idea of his character and works, than to suppose his benevolent regards confined to our comparatively diminutive world; that it is more accordant with the *infinity* and *eternity* of the Divine Being, and with his *wisdom* and *benevolence*, than the opposite position; that wherever any one perfection of Deity is exerted, there also *all* his attributes are in operation; and, consequently, wherever Omnipotence is seen to operate, there likewise wisdom, benevolence, rectitude, and every other Divine perfection must be displayed in reference to intelligent beings; that there is *an absurdity involved* in the contrary supposition; that this supposition would represent the universe as an immense desert, unworthy of the contemplation of intelligent minds; that it would prevent the progressive expansion of intellectual views in a future state, and present a distorted view of the character and attributes of the Almighty Creator. All these arguments and considerations, when viewed in a proper light, tend to yield a mutual support to each other; they hang together in perfect harmony, and they are in full consistency with the most amiable and sublime conceptions we can form of the Divinity, and therefore ought to carry irresistible conviction to the mind of every unbiased and intelligent inquirer. To my own mind they amount to *a moral demonstration*; so that I am as fully convinced of the truth of the position we have been maintaining, as if I were transported to the regions of distant worlds, and permitted to mingle in association with their inhabitants.

CHAPTER XVII.

A PLURALITY OF WORLDS PROVED FROM DIVINE REVELATION.

It is somewhat difficult to persuade the greater part of mankind that there are any habitable worlds besides our own, or that rational beings, somewhat analogous to man, may inhabit the planets of our own or of other systems. Even the greater part of Christians, and some who are possessed of a considerable degree of intelligence, can scarcely be persuaded that there are more worlds than one, or that the Divine government extends beyond the Christian church and the nations of the earth; and they attempt to vindicate their opinion by asserting, that the Scriptures never make the least allusion to any world except that in which we dwell. Although this were in reality the case, it would form no argument against the doctrine of a plurality of worlds; for the revelations contained in the Scriptures are chiefly of a *moral* nature, their great object being to counteract the depravity of man, and to afford information respecting the plans, and perfections, and moral government of the Divine Being, which the unassisted light of nature was unable to explore. They were not intended to teach us the principles of physical science, or the particular knowledge of any other subject which the human faculties were of themselves adequate to acquire; but to direct us, in all our surveys of the works of God, to look upward to him as the Supreme Agent, to trace his attributes in all his operations, and to offer him a tribute of grateful adoration. The Scriptures, therefore, would be fully sufficient to answer all the purposes of a revelation to man, although they made no allusion to other worlds or to other intelligences within the range of the Divine government.

Since the system of nature, the system of revelation, and the rational faculties of man, had their origin from the same Almighty Being, we should naturally expect that they should perfectly harmonize in their grand lineaments, and in the truths they are calculated respectively to unfold; or, at least, that there should be no glaring contradictions between the intimations given by the one and by the other. If the investigations

of reason in regard to the material universe necessarily lead to the conclusion that numerous worlds exist throughout immensity, and if the Scriptures contain a communication from God, we should never expect to find in that revelation any proposition asserting that there is only one world and one race of intelligent beings in the universe, and it is needless to say that no such proposition is to be found in the Bible. On the contrary, though the Scriptures never directly or explicitly treat of this subject, the doctrine of a plurality of worlds *is imbodied in many passages of the sacred writings;* and the language of the inspired penmen is in all cases perfectly consistent with the idea of myriads of worlds existing throughout the universe. To illustrate this position, in a few instances, is the object of this chapter; and as the passages of Scripture in which this sentiment is imbodied are more numerous than is generally apprehended, I shall select only a few of them as the subject of comment and illustration.

The first passage on which I shall offer a few remarks is Psalm viii., 3, 4: "When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained; what is man, that thou art mindful of him! or the son of man, that thou visitest him!"

When composing this hymn of praise to God, the Psalmist evidently appears to have been contemplating, with intelligence and pious emotion, the glories of the nocturnal sky, the moon walking in brightness along the canopy of heaven, and the stars and planets diffusing their lustre from more distant regions. Viewing those resplendent orbs, his thoughts seem to have taken a flight into the regions of immensity, and by the guidance of his rational powers, and aided by the spirit of inspiration, he takes an expansive view of the multitude, the magnitude, and the grandeur of those magnificent orbs which roll in the distant tracks of creation. Overwhelmed with his views of the immensity of the universe, and of the perfections and grandeur of its Creator, he breaks out into this striking exclamation, "Lord! what is *man*, that thou art mindful of him! or the son of man, that thou visitest him!" Surveying with his intellectual eye the boundless extent of God's universal empire, he shrinks, as it were, into nothing, and seems almost afraid lest he should be forgotten or overlooked amid the immensity of beings over which the Divine government extends. Now there could be no emphasis or propriety in this exclama-

tion if the inhabitants of this globe were the only rational beings that peopled the material universe; for if man is the principal inhabitant of creation, it could be no matter of wonder and astonishment that God should be "mindful of him," and exercise towards him a special regard and superintending care. Such a minute attention and affectionate regard is nothing more than what we should have naturally expected. But if the immensity of space be diversified with ten thousand times ten thousand worlds, replenished with rational inhabitants, as science and right reason demonstrate; if the race of Adam appear no more in the proportion to the beings that people the amplitudes of creation than as a drop to the ocean, then the Divine condescension appears truly wonderful and astonishing; that, from the heights of his glory in the heavens, the Most High should look down with an eye of complacency on the puny inhabitants of earth, and regard them with a Father's attention and care. This is evidently the leading idea which the pious exclamation of the Psalmist is intended to convey; and therefore, if this globe were the only or the principal abode of rational beings, such language would be mere hyperbole, or something approaching to bombast, which would be inconsistent with the veracity and solemnity of an inspired writer.

It appears, then, that the passage under consideration is not only consistent with the doctrine of a plurality of worlds, but necessarily imbodies in it the idea of the Divine empire being indefinitely extended, and comprising within its range numerous orders of exalted intelligences. It likewise teaches us, that while the Almighty has diversified the fields of immensity with innumerable worlds; that while he sits enthroned on the magnificence of his works in the distant regions of his creation, and governs the affairs of unnumbered orders of intellectual existence, *he also exercises the minutest superintendence over every world he has created*, however diminutive in comparison of the whole. His eye rests on the humblest and the minutest of its objects, and his Spirit watches over it as vigilantly as if it formed the sole object of his physical and moral administration; so that neither man nor the smallest microscopic animalculæ are overlooked amid the multifarious objects of the Divine government. This is an attribute *peculiar to the Most High*, which flows from the immensity of his nature and the boundless knowledge he has of all his works, and

which gives us a more glorious and sublime idea of his character than if his regards were confined to one department of his empire or to one order of his creatures; and in nothing is the Divine Being so immensely separated from man, or from any other rank of intelligent existence, as in the display he gives of this wonderful and incommunicable attribute. By overlooking this peculiar characteristic of the Divinity, and attempting to compare his procedure with the limited conceptions of our own minds, we are apt to indulge in very contracted and erroneous views respecting his nature and universal government, as well as in regard to the revelations of his word and the dispensations of his providence.

The next passage I shall notice is Isaiah xl., 15, 17: "Behold, the nations are as a drop of a bucket, and are counted as the small dust of the balance." "All nations before HIM are as nothing, and they are counted to him less than nothing and vanity."

In the chapter from which these words are taken, the prophet announces deliverance from the captivity of Babylon, and the approach of that period when "the glory of Jehovah shall be revealed, and when all flesh shall see it together." In order to obviate every difficulty that might seem to stand in the way of the accomplishment of such a glorious event, the prophet describes, in the most sublime language, the perfections and character of him by whose agency this astonishing change in the world was to be introduced. He is declared to be that Almighty Being "who measures the ocean in the hollow of his hand, who meteth out the heavens with the span, who comprehendeth the dust of the earth in a measure, and weigheth the mountains in scales, and the hills in a balance." The prophet likewise denounces the folly and wickedness of idolatry, by exhibiting the character and operations of him whom no material images, however splendid, can ever represent or adumbrate. "He sitteth on the circle of the sky which surrounds the earth, and the inhabitants thereof are as grasshoppers; he stretcheth out the heavens as a curtain; he bringeth forth their host by number; he calleth them all by their names, by the greatness of his might; for that he is strong in power, and there is no searching of his understanding." Among these sublime descriptions are contained the passages I have quoted: "Behold, the nations are as the drop of a bucket." "All nations before him are as nothing," &c.

Such declarations could scarcely be made with propriety if all the rolling orbs of heaven were destitute of inhabitants; for then it would not be true that "all nations are as the small dust of the balance," and that they are "counted to Jehovah as less than nothing and vanity." They who deny the doctrine of a plurality of worlds assume the position "that man holds the principal station in the material universe;" but, were this the case, then the nations of the earth, and "their multitude and glory," behooved to be considered as the greater portion, or as one of the greater departments of the Divine empire; and if so, it would be approaching to extravagance and bombast for any one to declare that they are only like a drop compared with the ocean, like a few particles of dust compared with a mighty island, or, in comparison with other departments, that "they are as nothing, and less than nothing and vanity."

We are here to consider the comparisons and contrasts drawn in those passages as referring, not to Jehovah, abstractedly considered, but to the *manifestations* he has given of his power, wisdom, and grandeur in the scenes of the universe. Hence we are directed, in the chapter from which our quotations are taken, to "lift up our eyes on high," and contemplate "the firmament of his power;" to "behold the hosts" of resplendent globes which he has dispersed throughout the regions of space "by the greatness of his strength," and to consider that the vast extent of the celestial spaces have been "meted out with the span." When the inspired writers demand from their hearers a sentiment of reverence and admiration, they do not present to them metaphysical reasonings or abstract views in reference to the perfections of Jehovah, but describe those exhibitions of his power and grandeur which are calculated to strike the senses and imagination, and to excite the emotion intended. Thus, when the prophet Jeremiah wished to impress his hearers with a reverential sense of the greatness of God, he describes him by the *effects* of his power and wisdom as displayed in his operations. "Who would not fear thee, oh King of nations! He hath made the earth by his power, he hath established the world by his wisdom, and hath stretched out the heavens by his discretion. When he uttereth his voice, there is a noise of waters in the heavens, and he causeth the vapours to ascend from the ends of the earth; he maketh lightnings with rain, and bringeth the wind out of his treasures."

In like manner, in the passages under consideration, we are to consider the contrast here stated as drawn, not between all nations and Jehovah as an abstract Being, whose perfections are infinite; for in this respect no comparison can be made, but as drawn between this earth with all its inhabitants, and the innumerable globes which are scattered throughout the regions of immensity. And the most enlightened astronomer, after his boldest excursions into the illimitable tracks of creation, could devise no language to express his emotions, and the contrast that subsists between this globe and the immensity of the heavens, more appropriate and energetic than the passage before us. This world, with "all that it inherits," is here represented as a single drop of water to the mighty ocean, or as a few particles of dust to the most spacious continents, when compared with the grandeur and immensity of nature; yea, to complete the contrast, it is "counted as nothing, and less than nothing and vanity." When we survey the vast globes which compose the planetary system; when we wing our flight in imagination to the starry regions, and leave the sun and all his attendants behind us, till they dwindle to an undistinguishable point; when we prosecute our course through thousands of nebulæ, every one of them containing unnumbered suns and systems; and when the mind is bewildered and overpowered at the immensity of the prospect, we cannot but perceive that the language of the prophet is the most impressive, and the fittest that could have been selected; that it is most emphatic, and literally true. But if this earth were the principal part of God's universe, there could be no propriety in such language, and it could be considered as allied only to extravagance and pompous declamation; a characteristic which ought never to be applied to the writers of the sacred records.

We ought likewise to consider, that the contrast is not stated between the earth, considered merely as a *material system*, and the amplitudes of the firmament, but between *the nations of the earth* and the innumerable order of beings which people the universe, plainly implying, in my apprehension, that unnumbered myriads of intelligences occupy the celestial worlds, in comparison of which all who now dwell upon the earth, or who have occupied its surface since time began, are only as a drop to the ocean. The passage before us may therefore be considered as almost a direct intimation of a plu-

rality of worlds; and if it could be proved that no other worlds existed, I should scarcely consider the strong language here used as the dictate of inspiration; but when we consider what appear to be the true references of the prophet's language, and the magnificent ideas it suggests, it conveys the most glorious and sublime conceptions of the grandeur of "the high and lofty One who inhabiteth eternity," and whose presence fills the immensity of creation.

The next passage I shall adduce in support of the position under consideration, is Nehemiah ix., 6: "Thou, even thou, art Lord alone; thou hast made heaven, the HEAVEN OF HEAVENS, with all their host; the earth, and all things that are therein; the seas, and all that is therein; and thou preservest them all; and the HOST OF HEAVEN worshippeth thee."

Here the Most High is represented, not by a metaphysical exhibition of his infinity, eternity, and omnipotence, abstractedly considered, but by the *manifestations* he has made of himself in his wonderful operations, both in heaven and on earth; and this is the general, I may say universal, mode in which the sacred writers exhibit the character and perfections of the Deity. "Thou hast made heaven, the heaven of heavens, with all their host." By "heaven" is here to be understood the visible firmament, with all the stars and planets perceptible by the human eye, which is the sense in which the term heaven is generally taken when God is represented as its Creator. The "heaven of heavens" is an expression which is worthy of particular attention, and evidently includes in it an idea far more extensive and sublime than what most readers generally attach to it. It evidently intimates that, far beyond the visible starry heavens which we behold, there are unnumbered firmaments, composed of other stars and systems, stretching out towards infinity on either hand, and which mortals in their present state will never be able to descry. We have already attained some glimpses of such firmaments. More than a hundred millions of stars, in addition to those distinguishable by the naked eye, are within the reach of the telescope, if all the regions of the sky were by this instrument thoroughly explored. We behold several hundreds, and even thousands, of *nebulæ* in different spaces of the heavens, each of them consisting of thousands of stars, which would form a firmament as glorious and expansive as that which appears to a common observer in the midnight sky; so that,

were we removed from one of those nebulæ to another, we should behold at every stage a new firmament, composed of stars or other luminaries altogether different from what we had seen before, or from what we perceive in the firmament which is visible from our globe. These facts, which have been brought to light by the discoveries of modern astronomy, while they discover the infinite power and grandeur of the Divinity, serve likewise to illustrate many of the declarations of his word, and particularly such expressions as that before us, "the heaven of heavens," the boundless empire of the "King eternal and invisible," in which he reigns over unnumbered intelligences. The same emphatical expression is used in the prayer of Solomon at the dedication of the temple: "But will God in very deed dwell on earth? Behold, the heaven and heaven of heavens cannot contain thee!" implying that far beyond the range of the material universe, vast and extensive as it is, the great Jehovah resides in the glory of his invisible attributes, filling immensity with his presence.

By "*the host of heaven*" is doubtless to be understood the inhabitants of those numerous worlds and vast regions here designated by the most emphatic expression which could be selected, "the heaven of heavens;" intimating that the same Almighty Being who launched into existence those innumerable globes, also replenished them with countless orders of intelligent existence, capable of enjoying his bounty, and offering to him a tribute of adoration. Hence it is here declared, "the host of heaven *worshippeth* thee;" evidently implying, if there is any rational idea to be elicited from the passage, that the bodies which compose "the heaven of heavens" are occupied with inhabitants; that these inhabitants are endowed with capacious powers of intellect; that their numbers correspond with the amplitude of the regions which they occupy; that most, if not all of them, are invested with the attribute of moral perfection, and are consequently in a state of happiness; that they employ their faculties in contemplating the perfections and operations of their Creator; and that they magnify and adore him in the loftiest strains, as the centre and source of all their felicity: all which appears to be implied in the passage, "the host of heaven worshippeth thee." For no being can with propriety be said to worship Jehovah, unless such as are endowed with moral and intellectual powers, capable of appreciating his perfections, as displayed in the universe, and

of perceiving that he is worthy of all homage and adoration. In accordance with such views, the Psalmist, when his soul was inspired with the higher strains of devotion, in a sublime apostrophe, calls upon the whole intelligent universe to adore the name of Jehovah: "Praise ye Jehovah from the heavens; praise him, ye heaven of heavens," or ye *inhabitants* of those higher regions; "praise him, all ye his angels; praise him, all ye his hosts. Let them praise the name of the Lord, for his name alone is exalted, and his glory is above the earth and heaven." If, therefore, there were no other worlds than that on which we dwell, such magnificent expressions would lose all their sublimity, would be almost without meaning, and might be regarded rather as the turgid exclamations of an enthusiast than as the sober dictates of inspiration. But when we take into view the immensity of the universe, and the numerous worlds and beings it contains, such expressions, though among the strongest which human language can furnish, fall far short of communicating the lofty ideas they are intended to represent.

Such passages as the following may likewise be considered as imbodying views of the same description: Psalm ciii., 19, "The Lord hath prepared his THRONE in the heavens; and his kingdom ruleth over all."

This, along with a number of similar passages interspersed throughout the Scriptures, evidently implies that *the heavens* form the principal part of the Divine empire, compared with which this earth is but as a point, and "all its inhabitants reputed as nothing." They are represented as the chief and appropriate residence of Jehovah, where he displays the glory of his perfections to unnumbered intelligences. Hence he is declared to have "*established his throne* in the heavens," intimating, that it is in those higher and more expansive regions that the principal arrangements of his government have been made, that the beneficence and rectitude of his character are manifested, and that the grandeur of his moral administration is most extensively displayed. But it is evident, that where there are no intellectual beings there can be no moral government; and therefore, if the Almighty has a government in the heavens, these heavens must be peopled with beings endowed with moral and intellectual faculties, capable of being the subjects of a moral administration. To suppose a government without subjects is evidently preposterous and ab-

sand. It is added, "His kingdom ruleth over all." Wherever these expansive heavens extend, and however numerous and august the worlds and systems which lie within their range, they are all under the superintendence and sway of the Divine government, which extends its care and moral energies over the remotest regions of the universe. But as there can be no kingdom without rational and moral subjects, therefore, wherever the kingdom of Jehovah extends throughout the illimitable spaces of immensity, there must be myriads of beings endowed with rational and moral natures. Similar remarks might be made upon such declarations as the following: "The Lord, he is *God* in heaven above," intimating his rule or dominion over the worlds on high; "Behold, the heaven and the heaven of heavens is the Lord thy God's," intimating, likewise, that he presides in high authority over all the beings they contain; "Thine, oh Lord, is the greatness, and the glory, and the majesty; for all in heaven and in earth is thine. Thine is the kingdom, oh Lord, and thou art exalted above all;" "Heaven is my *throne* and the earth is my footstool;" "His kingdom is an everlasting kingdom;" "His dominion is an everlasting dominion;" and, "He doth according to his will *in the army of heaven*, and among the inhabitants of the earth." All these, and similar passages, imply *rule* and *dominion* over the inhabitants of the heavens; and, consequently, intimate that the celestial worlds are occupied by the subjects of the Divine government. It is not improbable that the expression which so frequently occurs in Scripture, "*the Lord of Hosts*," or the Lord of armies, has a particular reference to the universal dominion of Jehovah over the countless myriads which people the distant regions of creation.

Psalm cxlv., 9: "The Lord is good to all; and his tender mercies *are over all his works*."

The goodness of God, in innumerable modes and instances, is displayed, not only towards man, but to all the diversified orders of animated existence in this lower world. But it is not confined to this terrestrial sphere, but is diffused wherever his wisdom and omnipotence have prepared habitations for sensitive and intellectual beings. Hence it is here declared, that "his tender mercies," or the emanations of his goodness and beneficence, "are diffused *over all his works*;" implying that throughout the whole range of the material system, however far it may extend, the beneficence of the Deity is

displayed to numerous ranks of his sensitive and intelligent offspring; for, unless such beings exist throughout all places of his vast dominions, there could be no scope for the exercise of his benevolence, and of course it could not be said, with propriety to extend "over *all* his works." In the same point of view we may consider an analogous expression in Psalm cviii., and other places of Scripture: "Thy mercy is great above the heavens;" or, as Mr. Locke translates it, "Great is thy BOUNTY *above the heavens*;" an expression which leads us to conclude, that far beyond these visible heavens which the unassisted eye beholds, and even beyond the reach of all the orbs which the telescope has enabled us to descry, the Divine goodness shines in rich manifestations, diffusing felicity and ecstatic joy among unnumbered legions of happy existence; for "bounty" or "goodness" can have relation only to such beings.

In the following passage of Psalm cxlv., 10–13, it is declared, "All thy works shall praise thee, oh Lord, and thy saints shall bless thee. They shall speak of the glory of thy kingdom, and talk of thy power; to make known to the sons of men his mighty acts, and the glorious majesty of his kingdom. Thy kingdom is an everlasting kingdom," &c.

This passage may be considered as imbodying a prediction, that in the future ages of the church men of piety will acquire more elevated and comprehensive views of the extent and the grandeur of the universal kingdom of Jehovah, and will display a more enlightened zeal than in ages past, in exhibiting to their fellow-men the august operations of Omnipotence, and the magnificence of that empire over which the Most High presides. "They shall speak of the glory of Jehovah's kingdom, and talk of his *power*." If this kingdom were chiefly confined to the evanescent speck of earth on which we live, it would scarcely be worthy of the epithets which are here bestowed upon it. It is a kingdom of GLORY; it is a kingdom in which are displayed *mighty acts* or operations; it is a kingdom of *glorious majesty*; it is a kingdom in which are displayed "*power*," and "*greatness which is unsearchable*;" it is a "kingdom of all ages," and its administration will be carried forward throughout all the revolutions of eternity; "thy kingdom is an *everlasting* kingdom." Were its government conducted chiefly in reference to earth and its inhabitants, such descriptions of its grandeur could

scarcely be expected from inspired writers, nor would such a limited kingdom correspond to the majesty of an infinite, omnipotent, and eternal Being, who has the range of immensity as the theatre of his operations. But when we contemplate the universal kingdom of Jehovah extending throughout the unlimited regions of space; when we behold it filled with worlds of immense magnitude, and with systems of worlds in such a multitude and variety that no man can number them, we perceive at once that such a kingdom warrants the application of such lofty epithets and expressions as are here used; that it is indeed a kingdom displaying omnipotent "power," and "greatness unsearchable;" that it is connected with "mighty operations;" that it is invested with "glorious majesty;" and that it is worthy of everlasting duration. But as the idea of a kingdom necessarily includes *subjects*, and as the multitude of subjects constitute the chief glory of an empire, so we must necessarily admit that all the provinces of this celestial kingdom are replenished with inhabitants, or, in other words, *subjects* of the Divine government; without which it could have no "glory" nor "majesty," nor could it with propriety be entitled to the designation of "a kingdom."

Such passages as the following may likewise be considered as corroborating the preceding positions: Psalm cxiii., 4–6, "Who is like unto the Lord our God, who dwelleth on high? The Lord is high above all nations, and *his glory above the heavens.* He humbleth himself to behold *the things that are in heaven* and in the earth." "Thy goodness is great above the heavens, and thy truth reacheth to the skies. Thou art exalted, oh God, *above the heavens,*" &c.

These passages, and others of a similar import, imbody the general idea that the omnipotence and grandeur of the Divinity are displayed in regions far beyond that firmament which is visible from our globe by common observers; yea, beyond the utmost limits to which telescopic discoveries have conducted us; for "his glory is *above,*" or beyond, "these heavens." And if nothing but empty space existed beyond these limits, or mere matter without mind, it could scarcely be said that the Divine *glory* is displayed beyond these heavens. It is farther stated that the glory of the Almighty is so expansive, and that his universal kingdom extends through regions so immeasurably distant, that he may be said, speaking after the manner of men, "to *humble himself* when he

beholds *the objects in the heavens*" which lie within our observation. This declaration contains not only a sublime representation of the magnificence of the Divine nature and operations, but appears to me to imbody in it a demonstration of what we formerly asserted as highly probable, namely, that that portion of the universe which lies within the range of telescopic vision, and which contains so many millions of splendid suns and systems, is but a *small part* of the universal kingdom of Jehovah, compared with what lies beyond the utmost boundaries of human vision; for he is here represented as *humbling* himself when he looks down from the remoter glories of his empire on all that is visible to the view of mortals. To the same purpose is the pious exclamation of the Psalmist in the viiith Psalm: "Oh Lord, our Lord, how excellent is thy name in all the earth! *who hast set thy glory above the heavens!*" And if the glory of the Divinity be manifested in regions far beyond the visible firmament, we may rest assured that it consists in displaying his perfections, and communicating happiness to innumerable orders of rational beings, who are the subjects of his moral government.

I shall only farther offer a few cursory remarks on the following passages: Psalm xix., 1, "The heavens declare the glory of God," &c. The word *glory* in this and similar passages, when applied to the Divinity, denotes the display of his wisdom, goodness, omnipotence, and other attributes. The heavens, with all the host of rolling orbs which they contain, are here declared to manifest the "glory," or the infinite perfections, of Him who formed them. The number and magnitude of the opaque and luminous globes contained within the vast expansion of these heavens, and their astonishingly rapid motions, evidently proclaim his *omnipotence*; but if those bodies accomplished no end corresponding to the extent and grandeur of the means employed; if they were all so many expansive deserts, without any relation to intellectual existence, they could afford no evidences of wisdom and beneficence, and, consequently, could not be said, with any show of reason, to "declare the glory of God." In the visions recorded in the Book of Revelation, the celestial inhabitants are represented as falling down before the throne of the Eternal in acts of adoration, and proclaiming, "Thou art worthy, oh Lord, to receive glory, and honour, and power; for thou hast created all things." And in another scene they are intro-

duced as celebrating with rapture the Divine operations: "Great and marvellous are thy works, Lord God Almighty." "Blessing, and glory, and wisdom, and thanksgiving, and honour, and power, be unto our God for ever and ever." Similar remarks to the above might be made in reference to these ascriptions of praise and adoration. If creation were a kind of chaos, or wilderness void of inhabitants, and if wisdom, design, and goodness were not displayed in the Divine arrangements, there would be little to excite the *admiration* and devotional rapture of superior intelligences; and they could not be said with propriety to ascribe *wisdom*, and glory, and thanksgiving to God, while they behold no display of some of these attributes in the mightiest of his works. But we are told in various passages of Scripture that the Most High "established the world," or the universe, "by his wisdom, and stretched out the heavens by his understanding." In Psalm cxlvii., 4, it is declared, "He telleth the number of the stars; he calleth them all by their names." It is evident we are not to consider this declaration as expressive merely of an arithmetical idea, or something similar to the practice of an astronomer, who distinguishes the stars by certain letters, characters, or appellations; but as expressive of the intimate knowledge which the Almighty has of all those mighty orbs wherever dispersed throughout the regions of infinitude, and likewise his perfect acquaintance with all the intellectual beings, and the special arrangements connected with every one of them; a circumstance which conveys a most sublime idea of the omniscience and omnipresence of the Deity. Hence, in the words immediately following, the mind of the Psalmist, overpowered with this idea, bursts forth in this exclamation, "Great is our Jehovah, and of great power; his understanding is infinite."

In the Epistle to the Hebrews, chapter i., 2, and xi., 3, a plurality of worlds is declared: "Through faith we understand that *the worlds* were framed by the word of God, and that the things which are seen were not made of things that do appear." The Greek word *αἰῶν*, in this passage, is sometimes used to denote *an age* or *dispensation*, but is also frequently used to designate the material world; in which sense it must be taken in the passage before us, as is evident from its connexion, and from the subject on which the apostle is treating. It is to the visible or material world that our atten-

tion is here directed as having been produced from an invisible cause. The term αἰῶνας being used in the plural number, evidently intimates that there are more worlds than one, and that there may be thousands or millions; but, independently of this direct intimation of a plurality of worlds, the passages formerly quoted, when viewed in a proper light, and considered in all their references and bearings, may be considered as conclusive proofs of the same position, and as intimating to us, not simply a plurality of worlds, but extending our views of their number and magnificence as far as science has yet conducted us, and even beyond the range of astronomical discovery; for we are told that the Divine perfections are displayed "above," or beyond, the utmost range of "the visible heavens."

Many other passages besides the above might have been pointed out as bearing on the same subject, but the remarks already made on the passages which have been selected may serve as a key to illustrate many others, as they happen to occur to the intelligent student of the Scriptures. We read, for example, of the Almighty operating, by his moral government and arrangements, "among the army" or armies "of heaven," as well as "among the inhabitants of the earth;" and that the whole population of our world "is reputed as nothing in his sight." We find, in different portions of the Psalms, the inhabitants of the heavens and "the heaven of heavens;" the "angels who excel in strength;" "all his hosts," or legions of intelligences, "in all places of his dominions, who do his pleasure, hearkening to the voice of his word;" we find all these ranks of beings called upon to join in one united chorus of praise and thanksgiving to "Him whose name alone is exalted, and whose glory is above the earth and heaven." We read in the Book of Job, among many other descriptions of the grandeur of Deity, that "by his Spirit he garnished the heavens;" and that the astonishing displays of his omnipotence they contain "are but parts of his ways," and that "the thunder of his power none can understand." All of which representations, and many others, may be considered as imbodying the idea, not only of a plurality, but of myriads of worlds existing in the universe.

There is one general remark which may be applied to all that we have stated in this chapter, and that is, *It is not necessary to suppose that the inspired writers had revealed to them*

all the wonders of modern astronomy. They appear, in some instances, to have been ignorant of the precise meaning and the extensive references of the language they used. The prophets are said to have "inquired and searched diligently what manner of time the Spirit of Christ which was in them did signify, when it testified beforehand the sufferings of Christ and the glory that should follow;" intimating that they were partly unacquainted with the precise references of the predictions they uttered. They were only the *amanuenses* of the Divine Spirit, and were directed to such language as was accordant with the Divine economy and with the facts existing in the universe, although they themselves might not be aware of the grandeur of those objects to which their expressions referred; and the correspondence of their language with the phenomena of the heavens and the earth, and the discoveries of modern times, constitutes one evidence among others of the truth of Divine revelation.

CHAPTER XVIII.

ON THE PHYSICAL AND MORAL STATE OF THE BEINGS THAT MAY INHABIT OTHER WORLDS.

On the enunciation of this topic, some readers will probably be apt to surmise that the author is attempting to go beyond the range of subjects within which the human understanding should be confined. We have never seen the inhabitants of other worlds; we have been favoured with no *special* revelations respecting them; we have not even caught a glimpse of the peculiar scenery of the globes in which they reside, excepting a few portions of their celestial phenomena; and while we are chained down by the law of gravitation to this sublunary sphere, we cannot fly on the wings of a seraph to visit any of the distant orbs of the firmament. It is true, that on such a subject we cannot attempt to descend into particulars. But there are certain general and admitted principles on which we may reason, and there are certain phenomena and indications of design exhibited in the structure of the

universe from which certain general conclusions may be deduced; beyond such generalities I do not intend to proceed, nor to indulge in vague conjecture. There are many things of which we have acquired a certain degree of knowledge, and yet have never seen. We do not see the air we breathe, nor most of the gaseous fluids: we do not see the principle of life, or the rational spirit which animates our bodies; we cannot possibly see the Divine Being, although his presence pervades all space. But, in regard to all these objects, we have acquired a certain degree of information; and therefore, although we have never seen any of the inhabitants of other planets, and never will so long as we remain in our present abode, yet we may form some general conceptions respecting them, both as to their physical and moral state. All that I propose on this point may be comprehended under the following general remarks:

1. The planets, wherever they exist, in our own or in other systems, are inhabited by *sentient beings*. The formation of *material* fabrics, such as all the planetary bodies are, necessarily indicate that beings connected with *material* vehicles and organs of sensation were intended to inhabit them. The arrangements for the diffusion of light, heat, and the influence of the power of attraction, and other material agencies, evidently show that such agents were intended to act on beings formed with organical parts and functions, capable of being the recipients of impressions from them. All such beings, therefore, must be considered as furnished with bodies constructed with organical parts *analogous* to what we find in man or other animated beings on our globe; but the size and form of such bodies, the parts of which they are composed, the functions they respectively perform, their symmetry and decoration, and their powers of locomotion, may be very different from those which obtain in our sublunary world; and it is not unlikely, from a consideration of the *variety* which exists in the universe, that there is a certain difference, in these and other respects, in every planet and world that exists throughout immensity.

2. The principal inhabitants of the planets and other worlds are not merely sensitive beings, but are likewise endowed with *intellectual faculties*. This may be inferred from the scenery connected with their habitations. Connected with the planet Jupiter, we behold four splendid moons larger than

ours, performing their revolutions around it *in regular periods of time*, without the least deviation from their courses. The general aspect of these moons, their diversified phases and rapid changes, along with their frequent eclipses, must produce a sublime and variegated appearance in the nocturnal sky of that planet; while, from the surface of the moons themselves, the still more splendid appearance of Jupiter and the phases of the other moons will present a nocturnal scene of peculiar sublimity and magnificence. Connected with the planet Saturn, we find scenes still more august and diversified; besides seven large moons, two resplendent rings of vast extent surround the body of this planet, producing the most sublime and diversified phenomena, both to the planet itself and to all its satellites, adorning the firmament of those bodies with a splendour and magnificence of which we can form but a faint conception.* Were we permitted minutely to inspect the surfaces of these planets, we should doubtless find many beautiful arrangements in the scenery of nature with which they are adorned, probably far surpassing in picturesque variety and grandeur what appears on the surface of our globe. When we inspect the surface of the moon through a good telescope, we behold a beautiful diversity of extensive plains, of lofty mountains, in every variety of size and form; of plains and valleys surrounded with circular ramparts of hills; of mountains towering far above, and vales and caverns sinking far below the general level of the lunar surface, with many other varieties; and we have only to suppose the general surface of that orb adorned with vegetable productions somewhat analogous to those of our globe, in order to present a scene of picturesque beauty and magnificence.

Now it appears a natural, if not a *necessary* conclusion, that such grand and beautiful scenes could only be intended for the contemplation and enjoyment of beings endowed with rational natures, since mere sentient beings, such as the lower animals in our world, are insensible either to the beauties of the vegetable kingdom or the glories of the spangled firmament. If our globe had been created merely for the support of such beings, it is not probable that it would have been adorned with all the beautiful arrangements which now exist, and the splendid and diversified scenes with which it is furnished.

* For a particular description of the scenes here alluded to, the reader is referred to "Celestial Scenery," chap. viii.

The lion, the tiger, and the hyena find every accommodation they desire in dens, deserts, thickets, and forests; and they appear to feel no peculiar enjoyment in flowery fields, expansive lakes, beautiful landscapes, or the sublimities of a starry firmament. If, then, there were no rational intelligences in the planetary worlds, we cannot suppose that so many grand and magnificent arrangements as we find existing would have been made; particularly, we cannot suppose that the motions of the planets and their satellites would have been so accurately adjusted as to perform their revolutions with so much precision as we find they do. The regularity and precision of these motions are evidently intended to serve as accurate measures of *time* or duration, a circumstance which must always be a matter of importance to rational beings wherever existing, but which seems to be scarcely attended to, and perhaps not in the least appreciated, by merely sentient beings, such as the lower orders of animated nature which exist around us.

From what has been now stated, we may conclude that the inhabitants of the planets are not *purely spiritual* beings; for pure spirits, entirely divested of material vehicles, cannot be supposed to have a permanent connexion with any material world or system; nor could they be supposed to be affected by air, light, colours, attraction, or other material influences which operate on the surfaces of all the planetary bodies. If pure intelligences, disconnected with matter, exist in the universe, they must be conceived to have a more expansive range than the limits of any one globe, and those material agencies which affect the organs of sensitive existence cannot be supposed to operate upon them; and, consequently, their modes of perception must be altogether different from those of organized intelligences. We may therefore, with certainty, conclude that the intelligent beings connected with the planetary worlds, either of our own or of other systems, are furnished with *bodies*, or corporeal vehicles of some kind or other. These may differ in size and form in different planets; perhaps their size may depend on the amplitude of space which the different planets may contain. But I cannot acquiesce in a supposition lately thrown out by a certain reviewer, that "in some worlds the inhabitants may be as large as mountains, and in others as small as emmets." In the one case, comparatively few inhabitants could live in a world where every one was a walking

Mount Blanc or Mount Etna; and it would be contrary to all the known arrangements of the Creator, who appears to act on the principle of compressing into a small space the greatest degree of sensitive and intellectual enjoyment. Besides, such a huge mass of matter as a mountain is not only unnecessary, but in all probability would be highly injurious to the exercise of the intellectual faculties. In the other case, were rational beings as small as emmets, they could neither contemplate the beauties and sublimities of the scene of nature around them, nor the glories of the starry firmament; their range of vision could extend only a few feet or yards around them, and they never could be able to explore the nature, extent, and peculiarities of scenery of the world they inhabited. So that all such suppositions are evidently extravagant and absurd, being directly contrary to the proportion and harmony which exist in the universe, and which characterize all the arrangements of the Creator. In regard to the powers of locomotion, there may be considerable difference in different worlds. In many instances there is reason to believe their inhabitants are enabled to transport themselves from one region to another with a velocity far surpassing the locomotive powers of man. In the planet Venus some of the mountains are reckoned to be twenty-two miles in perpendicular elevation, from the top of which eminences the most sublime and diversified prospects must be enjoyed; and in order that its inhabitants may be enabled to ascend with ease such lofty elevations, it is not unreasonable to believe that they are endowed with powers of motion far superior to those of the inhabitants of our globe.

3. The inhabitants of the planets are furnished with organs of sensation, particularly with *the organ of vision*. This may be certainly deduced from the fact that there are connected with the planets arrangements for the equable *distribution of light*. The sun, the source of illumination, is placed in the centre of the system for diffusing light in certain proportions over the surface of all the planets, their satellites, and their rings. Each planetary body revolves round its axis, in order that every part of its surface may alternately enjoy the benefit of the solar radiation. Around the larger planets are moons for the distribution of light in the absence of the sun; and one of them is invested with a splendid double ring, which reflects the solar rays during night both on the surface

of the planet itself and on the surfaces of its moons. This diversified apparatus for the diffusion of light evidently appears to be the arrangement of *means* in order to the accomplishment of an *end*; for it would be a reflection on the character of the All-wise Contriver to suppose that means have been arranged where no appropriate end is intended to be accomplished; but all the arrangements for the regular and equable diffusion of light have been made in vain, if there be no *eyes* or organs of vision on which light may act; for mountains, and vales, and barren deserts do not require its regular influence. That there are beings furnished with visual organs throughout all the worlds and systems of matter in the universe, appears from the consideration that not only in our own system, but among the myriads of fixed stars dispersed throughout immensity, provision is made for such organs in the existence of *light*, which is a substance that appears to be universally diffused throughout creation. It is found by experiment, that the light which radiates from the most distant star is of the same nature as that which emanates from the sun. It is refracted and reflected by the same laws, and consists of the same colours, as that which illuminates the bodies which compose the solar system, and which throws a lustre on the objects immediately around us. The mediums of vision must therefore be acted upon by light, in the most distant regions of creation, in nearly the same manner as with us, although there may be numerous varieties and modifications of the visual organs, so as to render vision far more perfect and extensive than in the case of the inhabitants of our globe. We find that there is an immense variety in the modes of vision among the lower animals. Some of the smaller insects have their eyes nearly of a globular form and very small, so that they can see only a few inches around them; while the eyes of other animals, such as the eagle, are so constructed that they can perceive their prey at a great distance, and from a very elevated position. Some animals have only one or two visual organs or eyeballs, as man, birds, and quadrupeds; others have eight, as in the case of spiders; and others have several hundreds, and even thousands, of transparent globules, each of which is capable of forming a distinct image of any object, as is the case with flies, butterflies, and other insects. All these diversified constructions of the organs of vision, however, perform their functions according to the same invariable laws of optics.

But, although light must act on the eyes of all organized beings in a manner somewhat similar, or, at least, analogous to what it does on our organs, yet there may be certain configurations of the organ of vision by which a more glorious and extensive effect is produced than by the human eye. The inhabitants of some other worlds, instead of being confined in their range of vision as we are, may be able to penetrate through space to an indefinite extent, and to perceive with distinctness all the prominent objects connected with neighbouring worlds; and even the peculiarities of distant suns and systems may be within the range of their view. The *difference* between the eye of an insect, which sees only an inch or two around it, and the eye of man, which can grasp at once an extensive landscape, is perhaps as great as the difference between the vigour and extent of human eyes and such organs of vision as I have now supposed. And who shall set boundaries to the mechanisms of Infinite Wisdom, especially when we consider the varieties which exist in our terrestrial system? It is not beyond the limits of probability that an inhabitant of Jupiter may be able to perceive and to trace all the variety of scenery connected with Saturn, and its rings and satellites, and to distinguish the planets that revolve around other suns, as distinctly as we perceive with a telescope the satellites with which that planet is attended. We have experimental proof that the inventions of art can extend the range of human vision. The rings of Saturn, the motions of its satellites, the changes which happen in the belts of Jupiter—which no unassisted eye could ever have discerned—and millions of stars a thousand times more distant than the limits of natural vision, have been brought to view by the invention of the telescope; which shows that the extent of human vision is susceptible of an indefinite increase. And if man can improve his natural vision, we need not doubt that the Deity has infinite resources at his command, and that, when he pleases, he can construct visual organs of such vast and extensive powers as far surpass the limits of our comprehension; and it is not improbable, from the variety already known to exist, that such organs are actually to be found throughout different regions of the universe. Our extent of vision by the telescope is found to depend on the extent of area contained in the object-glass or speculum of that instrument, which enables the eye to take in a greater portion of

rays from distant objects than it can do in its natural state; and therefore, if our eyes were formed with pupils of a large dimension, and with a corresponding degree of nervous sensibility in the retina, we might be enabled to penetrate into space to an extent of which we have no conception. Such modifications of vision, and thousands of others, are obviously within the power of Him who at first organized all the tribes of animated existence.

It is highly probable that it is one great design of the Creator to exhibit to all intelligent beings throughout creation a visible display of his glory through the medium of their visual organs; for where no organs of vision exist, the wonderful apparatus for the production and distribution of light, so conspicuous throughout the universe, exists in vain; and therefore, if it be allowed to reason from the means to the end, or from the cause to the effect, we must admit that the universal diffusion of light throughout infinite space, from an infinite variety of bodies, must be intended to produce vision through the medium of organs similar or analogous to ours; in order that rational beings may enjoy the pleasures arising from this sense, and be enabled to appreciate the wonders of the universe and the perfections of its Creator. The variety of means and contrivances for the diffusion of *light* throughout creation is therefore a demonstrative evidence both of the *existence* of intelligent beings in other worlds, and that they are furnished with visual organs for the purpose of contemplating the objects which it renders visible.

4. The inhabitants of other worlds are invested with *locomotive powers*. This we may infer from the amplitude of space which every world contains, and from the consideration that they are social beings, and hold a regular intercourse with each other. We must, indeed, necessarily suppose that there are no rational beings confined to one spot or point of space, as a tree, a shrub, or any other vegetable; for if this were the case, there could be no improvement either in knowledge or in moral action, the capacity of the intellect could never be expanded, the variety of beauties and sublimities which distinguish all the works of God could never be properly contemplated, most of the pleasures peculiar to an intelligent being could never be enjoyed, and the manifold delights which flow from social intercourse and the contemplation of diversified scenes and objects could never be experienced. The

supposition of an incapacity for local motion is therefore inconsistent with the idea of a rational being, and almost involves an absurdity. We find, moreover, that in many of the planets, particularly in Jupiter and Saturn, there is the most ample space provided for exercising the powers of locomotion; these two planets containing more than 220 times the area of the earth's surface, which affords a vast field for excursion and for observation to their inhabitants. These locomotive powers may be very different from those of man, both in their fleetness and in their mode of operation. We have reason to believe that in many instances they will far exceed ours, in swiftness, and in the ease with which they may be performed; for if birds and flying insects, and even certain quadrupeds are endowed with powers of motion far more swift and energetic than those of man, it is highly probable that rational and social beings, in more expansive worlds than ours, are capable of traversing space with much more ease and agility than the human inhabitants of our globe, otherwise they could not be supposed for ages to accomplish a survey of the world in which they dwell, or to become acquainted with its leading features. Whether such motions, however, are performed on a principle analogous to that on which the wings of birds are constructed, or on any other principle to us unknown, is beyond our province to determine.

5. We may also infer that the inhabitants of other worlds are furnished with a sense corresponding to *the organ of hearing*, and *a faculty of emitting articulate sounds*. Without such a sense and faculty, it is scarcely possible to conceive that social intercourse, and a mutual interchange of sentiment and feeling, could be carried on to any extent, or with any great degree of pleasure or improvement, among organized beings. Pure spirits may have modes of intercourse and of communicating thought peculiar to themselves, of which we can at present form no distinct conception; but organized intelligences must necessarily have some *material* mediums or faculties by which sentiments and emotions may be expressed and communicated. Some of the planets are found to be environed with atmospheres; and, as air is the medium of sound in our terrestrial region, it doubtless serves a similar purpose in other worlds; and, consequently, we may conclude, that the animated beings they contain are furnished with organs for the perception of sounds in all their modulations.

In the representations given in the sacred records of the exercises of superior beings, they are exhibited as uttering articulate sounds, and joining in the harmonies of music. When a multitude of angels descended on the plains of Bethlehem to announce the birth of Messiah to the shepherds, they uttered articulate sounds, and joined in musical strains which struck the ears of the shepherds, and conveyed a distinct impression of the meaning of the sentiments communicated; which circumstance leads us to conclude, that superior intelligences in other regions express sentiments and emotions in a manner somewhat similar to that in which we hold intercourse with one another, by the faculties of speech and hearing.

6. It might, perhaps, be inferred, from the *rotation* of the planets—which produces the alternations of light and darkness—that their inhabitants are subject to something analogous to *sleep*, or stated intervals of repose. This may probably be the case in some of the planets, such as Mars or Mercury, which are unaccompanied with satellites; but we know too little of the peculiar circumstances of other worlds to warrant us to speak decisively on this point, as the bodies of the inhabitants of other planets may be so constructed as not to stand in need of being daily invigorated by repose as the bodies of men. Besides, the celestial scenery of some of the planets is so grand, diversified, and picturesque, that a considerable part of their studies and social pleasures may be prosecuted and enjoyed amid the solemn grandeur and beautiful diversity of their nocturnal scenes, and their contemplations directed to the interesting objects then presented to their view. This is probably the case in the regions of Jupiter and Uranus, particularly in Saturn, where seven moons may occasionally be beheld in the nocturnal heavens, all exhibiting different *phases*, some of them changing their apparent phases, magnitude, and motion with great rapidity; some of them entering into an eclipse, and others emerging from it; while two stupendous rings stretch across the concave of the sky, presenting every moment different objects on their surface in the course of their rapid diurnal revolution. Such scenes will, perhaps, be more interesting to the inhabitants of this planet than all the splendours of their noonday;* for all the objects on the surface of this planet, and likewise those on Jupiter and

* For a particular description of these scenes, the reader is referred to "Celestial Scenery," chap. viii., p. 329–364.

Uranus, will present a different aspect from what they do in the daytime. Being illuminated by the light reflected from a retinue of moons, and by the still more effulgent splendour emitted from the spacious rings, every object will appear enlightened and distinctly visible, a diversity of colouring will be exhibited by the diversity of reflected rays proceeding from the different moons and rings, and the shadows of objects will be increased and blended together, and thrown in different directions, according to the number and relative positions of the nocturnal luminaries which may happen to be above their horizon. On which account I should be disposed to conclude that the inhabitants of such planets have their physical constitutions organized in such a manner by Divine Wisdom as to fit them for perpetual activity, without standing in need of any repose similar to that of sleep.

The above cursory remarks respecting the physical state of the planetary inhabitants have been deduced chiefly from the ascertained circumstances and phenomena of the planets, and from the general constitution and economy of the universe. Several other conclusions might likewise have been deduced, but I do not intend to enter into the regions of mere conjecture. As rational and intelligent beings, the inhabitants of other worlds must necessarily be considered as prosecuting the study of useful science in reference to all those departments of nature which lie open to their inspection, and that they exercise their mental faculties in such pursuits and investigations. If this be admitted, then we must necessarily conclude that they use all the requisite means for the investigation of truth and for progressing in knowledge. If, for example, they engage in the study of astronomy (as we have reason to believe the inhabitants of all worlds do), they must make observations, both general and particular; and, in order to do so with accuracy and precision, instruments of various descriptions are requisite, and the management of these requires the use of *hands*, or some bodily parts answering a similar purpose; for none of the lower animals on our globe that are deficient in such a member could perform the operations of art which man can perform by the use of his hands. If a horse or a bear were furnished with the same intellectual faculties as the human race, and still retain its present organisation, it could make little or no progress either in science or art, without members corresponding to human hands; and

therefore we may confidently conclude that members similar or analogous to these are common to us and to the planetary inhabitants. The study of astronomy likewise supposes an acquaintance with *geometry*. The truths of geometry must be the same in every region of the universe, and perhaps of equal utility to the inhabitants of the most distant worlds as to man on earth. They are truths which are eternal and unchangeable, and which no locality or circumstances within the limits of creation can possibly alter or modify; and therefore must be recognised, in a greater or less degree, by every rational being. The Creator himself has laid the foundation of this science, for he presents us in his works with geometrical figures of various descriptions; with circles, squares, parallelograms, hexagons, and polygons; with ellipses, spheres, spheroids, and other figures, and proposes them, as it were, to our study and contemplation. With geometry, *arithmetic* and other sciences are intimately connected, so that the study of the one supposes that of the other. In short, truth, and every branch of knowledge by which the mind of a rational being can be adorned, must be *substantially* the same in every world throughout the amplitudes of creation.

Some persons, however, may be disposed to object, that the inhabitants of other worlds may see all truths *intuitively*, and that they may have no need to use any means, as we are obliged to do, to acquire and to make progress in knowledge, and that they acquire all their knowledge at once without any exertions; opinions which have been frequently broached by divines, in reference to the happiness of the future world. But there appears no foundation for such opinions. We have reason to believe that every intellectual being throughout creation *exerts* its powers for the acquisition of truth, and that its advancement in knowledge is *progressive*; for its faculties were bestowed for the very purpose that they might be exerted on all the different objects and manifestations of the Divinity within its reach; and if all knowledge were intuitive, and required no exertion of the mental faculty, the individual would be reduced to something like a mere machine, and would be deprived of the pleasures which arise from mental research and investigation. There must likewise be a *progress* in knowledge, arising from the consideration of the immensity of the Divine Being, and of his works, and of the limited nature of finite intelligences. No finite being can

ever grasp the incomprehensible Divinity, or the immensity and variety of his operations throughout boundless space; but it may always be *advancing* to a more comprehensive view of the perfections and the empire of the Eternal, and may thus go on, from one degree of knowledge to another, gradually approximating *towards* perfection during all the periods of an immortal existence, but will never reach it; and its happiness is connected with this circumstance, that it will never reach perfection, or obtain a *full discovery* of all the glories of the Divinity. But this gradual progression and expansion of intellectual views will be a perennial source of felicity to all virtuous intelligences. Whereas, were the whole of their knowledge acquired at once, or after a short period of duration, the mind would flag, mental activity would cease, the prospect of future knowledge and enjoyment would be cut off, and misery to a certain extent would take possession of the soul.

In fine, although there are, doubtless, marked differences between the planetary inhabitants and the inhabitants of our globe, and although the natural scenery of those worlds may be considerably different from ours, yet it is not improbable, were we transported to those abodes, that we should feel more at home in their society and arrangements than we are now apt to imagine, provided we were once made acquainted with their language or mode of communicating their ideas. For there are certain relations, sentiments, dispositions, and virtues, which must be common to intellectual and moral beings, wherever existing throughout the material universe. In respect to bodily stature and appearance, we might be apt to suspect that there would be many striking differences in the aspect of the inhabitants of another planet, and that strange and novel forms of corporeal organization would everywhere be presented to view; yet it is just as probable that in such a world we should contemplate beings not much unlike ourselves, and animated by similar or analogous views, sentiments, and feelings, though placed in circumstances and surrounded with a scenery very different from those of our sublunary region.

Whether we may ever enjoy an intimate correspondence with beings belonging to other worlds, is a question which will frequently obtrude itself on a contemplative mind. It is evident that, in our present state, all direct intercourse with

other worlds is impossible. The law of gravitation, which unites all the worlds in the universe in one grand system, separates man from his kindred spirits in other planets, and interposes an impassable barrier to his excursions to distant regions, and to his correspondence with other orders of intellectual beings. But in the present state he is only in the *infancy of his being*; he is destined to a future and eternal state of existence, where the range of his faculties and his connexions with other beings will be indefinitely expanded. "A wide and boundless prospect lies before him," and during the revolutions of an interminable duration, he will doubtless be brought into contact and correspondence with numerous orders of kindred beings, with whom he may be permitted to associate on terms of equality and of endearing friendship. All the virtuous intelligences throughout creation may be considered as members of one *great family*, under the peculiar care and protection of the UNIVERSAL PARENT; and it is not improbable that it is one grand design of the Deity to promote a regular and progressive intercourse among the several branches of his intelligent offspring, though at distant intervals and in divers manners, and after the lapse of long periods of duration.

Such an intercourse may be necessary, in order to the full expansion of the moral and intellectual faculties, and to the acquisition of all that knowledge which relates to the attributes of the Divinity, and the physical and moral government of the universe. For this purpose it may be necessary that branches of the universal family that have existed in different periods of duration, and in regions widely separated from each other, should be brought into mutual association, that they may communicate to each other the results of their knowledge and experience, the diversity of physical and moral circumstances in which they have been placed, and the different arrangements of God's moral government to which they have been respectively subjected. Such views correspond with the representations given in Scripture in reference to the heavenly state. The "spirits of just men made perfect" are represented as joining the society of "an innumerable company of angels," which are only another order of rational beings; and in the visions of celestial bliss, recorded in the book of Revelation, both men and the angelic hosts are exhibited as forming one society, and joining in unison in celebra-

ting the perfections of Him who sitteth on the throne of the universe.

But should the laws of the physical system, and the immense distances which intervene between the several worlds, prevent such associations as I have now supposed, there may be another economy, superior to the physical, which may consist with the most extensive and intimate intercourse of all rational and virtuous beings. There may be a *spiritual* economy established in the universe, of which the physical structure of creation is the basis or platform, or the introductory scene in which rational beings are trained and prepared for being members of the higher order of this celestial or intellectual economy. It appears highly probable that the first introduction of every rational creature is on the scene of a *physical* economy. The diversified scenes and relations of the material world appear to be necessary, in the infancy of being, to form a substratum for thought, or to afford scope for the exercise of the moral and intellectual powers, or materials on which these powers may operate, and likewise for exhibiting a *sensible* display of the character and perfections of the Almighty. The knowledge which may thus be acquired of the scenes and relations of the universe, and of the attributes and moral government of its Omnipotent Author, in the course of myriads of ages, must be great and extensive beyond what we can well conceive. This knowledge and experience of physical objects and relations may prepare the rational soul for entering on the confines of a higher and nobler economy, where *immaterial* scenes and relations, and particularly the attributes of Divinity, abstractly considered, may form the chief objects of research and contemplation. Under such a state or economy, we may conceive that intellectual beings, to whatever portion of the material universe they originally belonged, may hold the most intimate converse with one another, by modes peculiar to that economy, and which are beyond the conceptions of the inhabitants of the physical universe; so that distance in point of space shall form no insuperable barrier to the mutual communication of sentiments and emotions.

On grounds similar to those now stated, we might conceive it as not altogether improbable, that the spiritual principle which animates the lower orders of animated nature, and which in some cases bears a near resemblance to the reason of man, may be susceptible of indefinite expansion and improvement

by being connected with a superior organization, and that such beings may ultimately pass through various gradations of rank in the physical and intellectual economy, till they arrive at a station superior to that of the most enlightened and improved human beings. But as we are now bordering on the regions of doubt and uncertainty, suffice it to say, that it appears highly probable, from a consideration of the Divine benevolence, of the relations which subsist throughout the physical and intelligent system, and of the intimations contained in the records of revelation, that virtuous and holy intelligences, from different regions of the material creation, as brethren of the same great family, shall, at one period or another, hold the most intimate converse and communion, and rehearse to each other their mutual history and experience. Such intercourse would evidently enhance that felicity which it is the great design of the Creator to communicate, and the means by which it may be effected are obviously within the limits of infinite Wisdom and Omnipotence.

On the Moral State of the Inhabitants of other Worlds.

The moral state of intellectual beings in other worlds is a subject of still greater interest and importance than their physical state and constitution, and the scenes of nature with which they are surrounded; for on the moral temperament of such beings, and the passions and affections they display, will chiefly depend the happiness of the intelligent system throughout every region of the universe. It is possible to suppose a region of creation furnished with everything that is grand, beautiful, and magnificent, and calculated to gratify in the highest degree the senses and imagination, and yet the abode of wretchedness and misery. If passions and dispositions similar to those which actuate the most vicious and depraved class of mankind were universally to prevail in any world, however beautiful and sublime its physical arrangements, true happiness would be banished from its society, and misery, in all its diversified ramifications, would be found pervading its abodes. Even the tempers and dispositions which are frequently exhibited in polished society, and by some men who call themselves Christians and philosophers—jealousy, emulation, envy, pride, revenge, selfishness, and such like—were they to reign uncontrolled in any region, would soon transform intellectual beings into an assemblage of fiends,

and banish true enjoyment from every department of the social system.

If these sentiments be admitted, it will follow that, were we permitted to range through any of the planetary worlds, the pleasures and enjoyments of such an excursion would chiefly depend upon the character and dispositions of those who accompanied us, and of the inhabitants of the planet through which we roamed. Were we to be treated by the inhabitants of another world in the same way as Mr. Park was treated by the Moors when he was traversing the wilds of Africa, or as a poor wretched foreigner is sometimes treated in our own country, we should find little enjoyment amid all the beauties and novelties of scenery which might meet our eye in such a world; for upon the conduct of intelligent beings towards one another must depend the happiness of individuals, and of the whole social system throughout every department of creation.

It is probable that the greater part of the inhabitants of all worlds are in a state of innocence, or, in other words, that they remain in that state of moral rectitude in which they were created; for we may assume it as an axiom, that every rational being, when first ushered into existence, is placed in a state of innocence or moral rectitude, without any natural bias to moral evil. To suppose the contrary would be to admit that the Divine Being, who is possessed of perfect holiness and rectitude, infuses into rational beings at their creation a principle of sin or a tendency to moral evil, which would be inconsistent with every Scriptural view we can take of the character of God. Such beings, therefore, so long as they continue in their primeval rectitude, are in a state of happiness; and every arrangement of the Creator in relation to them must be conceived as having a direct tendency to promote their sensitive and intellectual enjoyment. Moral evil, however, has been introduced into the universe, and we know by experience many of its malignant and miserable effects. For anything we know to the contrary, the operation of the principle *may be felt* in some other worlds besides our own, though we have reason to believe, from a consideration of Divine goodness, that its effects are not very extensive. Its introduction into the world has doubtless been permitted in order to bring about a greater good to the universe at large than could have been accomplished without it, in order to ex-

hibit to the intelligent system a display of the miserable and extensive effects which necessarily flow from a violation of the original moral laws given forth by the Creator, and to demonstrate the indispensable necessity of a universal adherence to these laws, in order to secure the harmony and the happiness of the intelligent universe.

In conformity to the axiom stated above, we must necessarily suppose that rational beings, wherever existing, were created in perfect moral purity, and had a law or laws impressed upon their minds congenial to the holiness of the Almighty Creator, and calculated to promote the moral order of the intelligent system, and, consequently, the happiness of every individual belonging to it. *Moral order* consists in the harmonious arrangement, disposition, and conduct of intelligent beings, corresponding to the relations in which they stand to one another and to their Creator, and calculated to promote their mutual happiness. Wherever moral order prevails, every being holds its proper station in the universe, acts according to the nature of that station, uses its faculties for the purpose for which they were originally intended, displays dispositions and emotions towards fellow-creatures and the Creator corresponding to the respective relations in which they stand, and endeavours to promote enjoyment among all surrounding beings.* For the purpose of securing moral order, certain moral laws must be supposed to be promulgated by the Creator, or at least written upon the hearts of all rational beings, as principles of action, to regulate all the movements of the intelligent system. These laws must be *substantially* the same as to their general bearings throughout all the worlds in the universe.

But, it may be asked, what are those general laws to which I allude, and have they ever been promulgated to man upon earth? I answer, they have actually been revealed to the inhabitants of our globe by the highest authority, and reason can demonstrate their applicability to all worlds. They are these: "THOU SHALT LOVE THE LORD THY GOD WITH ALL THY HEART, AND WITH ALL THY MIND, AND WITH ALL THY STRENGTH. This is the first and great commandment. And the second is like unto it: THOU SHALT LOVE THY NEIGHBOUR AS THYSELF." These laws are not to be considered

* For a particular illustration of *moral order*, the reader is referred to "The Philosophy of Religion," *Preliminary Definitions*, sect. I.

as confined merely to the regulation of the affections and actions of human beings, but to every individual of the moral system, wherever existing; for we cannot for a moment suppose that laws directly opposite to these would be given by the Creator to any class of intelligences. It would be inconsistent with everything we know of the character of the Divinity to imagine that he would promulgate to any class of beings such laws as these: "Thou shalt hate thy Creator," and "thou shalt hate all thy fellow-creatures." And if such an idea would evidently involve in it a glaring inconsistency and absurdity, then it follows that the very opposite of such injunctions must be the general principles which govern the inhabitants of all worlds that have retained their allegiance to their Creator. There is not a single being possessed of a rational nature, either in the planetary system to which we belong or to any other system throughout the sidereal heavens, but is under indispensable obligations to regulate its conduct by the two general laws or principles to which we have referred, and to yield a complete and unreserved obedience to all that is included in such requisitions. Wherever such obedience is complete, order, harmony, and happiness are the natural and necessary results; but could we suppose these laws reversed, and the inhabitants of any worlds to act on principles directly opposite, a scene of anarchy, confusion, and misery would ensue, which would completely disorganize the social system, and render existence a curse rather than a blessing; and in worlds where those laws are *partially* violated, as in the world in which we dwell, disorder and misery will be the result in proportion to the frequency and extent of their violation.

These are the laws by which not only man on earth, but all "the principalities and powers of heaven," are governed and directed, and by which they are bound to regulate all their thoughts, affections, and conduct. The lowest orders of rational existence come within the range of these universal laws, and the highest orders of the seraphim are not beyond their control. As the law of gravitation extends its influence throughout all the planetary worlds, and even to the remotest stars, uniting the whole in one harmonious system, so the law of universal *love* diffuses its influence over the intelligent universe, uniting the individuals who are subject to its sway in one harmonious and happy association. Hence it follows,

that, were we completely animated by this noble principle, and were we permitted to visit those worlds where it reigns supreme, and to mingle with their inhabitants, we should be recognised as friends and brethren, and participate of all those pleasures and enjoyments of which it is the source. The full recognition, then, of the laws to which we have referred, and their complete and uninterrupted influence over the moral powers, may be considered as qualifying the individual for being a citizen of the great moral universe, and for associating with all holy beings throughout the wide empire of omnipotence, should he ever be permitted, at any period of duration, to visit other worlds, and mingle with other orders of rational intelligences.*

These laws, in reference to the inhabitants of our world, diverge into numerous ramifications. The precepts of the moral law, or the ten commandments, are so many branches of moral duty flowing from these first principles; and in the discourses of our Saviour and the practical parts of the apostolic epistles they diverge into still more specific and minute ramifications, bearing upon all the diversified relations of life and the various circumstances connected with moral conduct. But all the particular rules and precepts alluded to are resolvable into the general principles or affections stated above, and bear the same relation to each other as the trunk of a tree to its branches, or as a fountain to the diversified streams which it sends forth. In other worlds relations may exist different from those which are found in human society, and, consequently, particular precepts different from ours may form a part of their moral code, while certain relations which obtain among us may have no place among other orders of beings, and, of course, the precepts which particularly bear upon such relations will be in their circumstances altogether unnecessary. But we may rest assured that all the particular precepts, applicable to whatever circumstances and relations may exist in other regions of creation, will be founded on the universal principles to which we have adverted, and be completely conformable to their spirit, and to the benevolent designs they are intended to accomplish.

In all those worlds where the love of God and of fellow-intelligences reigns supreme, the inhabitants may be conceived

* For more particular details on this subject, the reader is referred to "The Philosophy of Religion," particularly chap. ii., sect. vi.

to make rapid improvements in knowledge; for the malignant principles and passions which prevail among men have, in numerous instances, been the means of retarding the progress of useful science and its diffusion throughout society. But where love in all its emanations pervades every mind, society will unite and harmonize in the prosecution of every plan by which the intellectual faculty may be irradiated and happiness diffused. Besides, in such a state of society, truth will be for ever triumphant and falsehood unknown. Every fact will be fairly and truly exhibited without deception, or the least tendency to misrepresentation or exaggeration. There will be the most complete reliance on personal evidence in regard to every fact and circumstance which has been witnessed by any individuals; for want of which confidence in our world, the rational inquirer has been perplexed by the jarring statements of lying travellers and pretended philosophers; erroneous theories have been framed, the mists of falsehood have intercepted the light of truth, the foundations of true knowledge undermined, and science arrested in its progress towards perfection. All such evils, however, will be unknown in worlds where the inhabitants have arrived at moral perfection.

In fine, from what has been now stated, we may conclude that the *spirit*, the *principle*, and *essence* of our holy religion, as delineated in the Scriptures, must be common to all the inhabitants of the universe who have retained their primeval rectitude and innocence.

CHAPTER XIX.

A SUMMARY VIEW OF THE UNIVERSE.

Having in the preceding pages offered a few sketches in reference to the principal facts connected with the sidereal heavens, which constitute the most extensive portion of creation within the limits of our knowledge, it may not be inexpedient to take a summary view of the range of objects to which our attention has been directed, in order to direct our occasional reflections on this subject, and to enable us

form an approximate, though faint and limited, idea of that universe over which Omnipotence presides, and of the perfections of its adorable Author.

We can obtain an approximate idea of the universe only by commencing a train of thought at those objects with which we are more immediately conversant, and ascending gradually to objects and scenes more distant and expansive. We are partly acquainted with the objects which constitute the landscape around us, of which we form a part; the hills, the plains, the lofty mountains, the forests, the rivers, the lakes, and the portions of the ocean that lie immediately adjacent. But all the range of objects we can behold in an ordinary landscape forms but a very small and inconsiderable speck, compared with the whole of the mighty continents and islands, the vast ranges of lofty mountains, and the expansive lakes, seas, and oceans, which constitute the surface of the terraqueous globe. It would be requisite that more than *nine hundred thousand landscapes*, of the extent we generally behold around us, should be made to pass in review before us, and a sufficient time allowed to take a distinct view of the objects of which they are composed, ere we could form an adequate conception of the magnitude and the immense variety of objects on the whole earth. Were only twenty minutes allotted for the contemplation of every landscape, and ten hours every day, it would require ninety years of constant observation before all the prominent objects on the surface of the globe could thus be surveyed. Were it possible to take a distinct mental survey of such a number of landscapes, we might acquire a tolerable conception of the amplitude of our globe, and it would serve as a standard of comparison for other globes which far excel it in magnitude. But I believe very few persons are capable of forming, *at one conception*, a full and comprehensive idea of the superficial extent of the world in which we dwell, whose surface contains no less than one hundred and ninety-seven millions of square miles. The most complete conception we can form must indeed fall very far short of the reality.

But, however ample and correct our conceptions might be, and however great this earth might appear in the view of the frail beings that inhabit it, we know that it is only an inconsiderable ball when compared with some of the planetary bodies belonging to our own system. One of these bodies

would contain within its dimensions nine hundred globes as large as this earth; another, fourteen hundred of similar globes; and were five hundred globes, as large as that on which we dwell, arranged on a vast plane, the outermost ring of the planet Saturn, which is 643,000 miles in circumference, would enclose them all. Such are the vast dimensions of some of those revolving bodies, which appear only like lucid specks on the concave of our sky. This earth, however, and all the huge planets, satellites, and comets comprised within the range of the solar system, bear a very small proportion to that splendid luminary which enlightens our day. The SUN is five hundred times larger than the whole, and would contain within its vast circumference thirteen hundred thousand globes as large as our world, and more than sixty millions of globes of the size of the moon. To contemplate all the variety of scenery on the surface of this luminary would require more than fifty-five thousand years, although a landscape of five thousand square miles in extent were to pass before our eyes every hour. Of a globe of such dimensions, the most vigorous imagination, after its boldest and most extensive excursions, can form no adequate conception. It appears a kind of universe in itself; and ten thousands of years would be requisite before human beings, with their present faculties, could thoroughly investigate and explore its vast dimensions and its hidden wonders.

But great as the sun and his surrounding planets are, they dwindle into a point when we wing our flight towards the starry firmament. Before we could arrive at the nearest object in this firmament, we behooved to pass over a space at least twenty billions of miles in extent; a space which a cannon ball, flying with its utmost velocity, would not pass over in less than four millions of years. Here every eye, in a clear winter's night, may behold about a thousand shining orbs, most of them emitting their splendours from spaces immeasurably distant; and bodies at such distances must necessarily be of immense magnitude. There is reason to believe that the least twinkling star which our eye can discern is not less than the sun in magnitude and in splendour, and that many of them are even a hundred or a thousand times superior in magnitude to that stupendous luminary. But bodies of such amazing size and splendour cannot be supposed to have been created in vain, or merely to diffuse a useless lustre

over the wilds of immensity. Such an idea would be utterly inconsistent with the perfections of the Divinity, and all that we know of his character from the revelations of his word. If this earth would have been "*created* in vain" had it not been inhabited,* so those starry orbs, or, in other words, those magnificent suns, would likewise have been created in vain, if retinues of worlds and myriads of intelligent beings were not irradiated and cheered by their benign influence.

These thousand stars, then, which the unassisted eye can perceive in the canopy of heaven, may be considered as connected with at least *fifty thousand worlds*; compared with the amount of whose population all the inhabitants of our globe would appear only as "the small dust of the balance." Here the imagination might expatiate for ages of ages in surveying this portion of the Creator's kingdom, and be lost in contemplation and wonder at the vast extent, the magnitude, the magnificence, and the immense variety of scenes, objects, and movements which would meet the view in every direction; for here we have presented to the mental eye, not only single suns and single systems, such as that to which we belong, but suns revolving around suns, and systems around systems; systems not only double, but treble, quadruple, and multiple, all in complicated but harmonious motion, performing motions more rapid than the swiftest planets in our system, though some of them move a hundred thousand miles every hour; finishing periods of revolution, some in 30, some in 300, and some in 1600 years. We behold suns of a blue or green lustre revolving around suns of a white or ruddy colour, and both of them illuminating with contrasted coloured light the same assemblage of worlds. And if the various orders of intelligences connected with these systems were unveiled, what a scene of grandeur, magnificence, variety, diversity of intellect, and of wonder and astonishment, would burst upon the view! Here we might be apt to imagine that the whole glories of the Creator's empire have been disclosed, and that we had now a prospect of universal nature in all its extent and grandeur.

But, although we should have surveyed the whole of this magnificent scene, we should still find ourselves standing only on the outskirts, or the extreme verge of creation. What if all the stars which the unassisted eye can discern be only a few scattered orbs on the outskirts of a cluster immensely

* Isaiah xlv., 18.

more numerous? What if all this scene of grandeur be only as a small lucid speck compared with the whole extent of the firmament? There is demonstrative evidence from observation that this is in reality the case. In one lucid circle in the heavens, scarcely perceptible on a cursory view of the firmament, there are twenty thousand times more stars distinguishable by the telescope than what the naked eye can discern throughout the visible canopy of heaven. The Milky Way, were it supposed to contain the same number of stars throughout its whole extent as have been observed in certain portions of it, would comprise no less than 20,191,000 stars; and as each of these stars is doubtless a sun, if we suppose only fifty planets or worlds connected with each, we shall have no less than 109,955,000, or more than *a thousand millions* of worlds contained within the space occupied by this lucid zone. Here an idea is presented which completely overpowers the human faculties, and at which the boldest imagination must shrink back at any attempts to form an approximate conception. A thousand millions of worlds! We may state such a fact in numbers or in words, but the brightest and most expansive human intellect must utterly fail in grasping all that is comprehended in this mighty idea; and perhaps intelligences possessed of powers far superior to those of man are inadequate to form even an approximate conception of such a stupendous scene. Yet this scene, magnificent and overpowering as it is to limited minds such as ours, is not the scene of the universe; it is only a comparatively insignificant speck in the map of creation, which beings at remote distances may be unable to detect in the canopy of their sky, or, at most, will discern it only as an obscure point in the farthest extremities of their view, as we distinguish a faint nebulous star through our best telescopes.

Ascending from the Milky Way to the still remoter regions of space, we perceive several thousands of dim specks of light which powerful telescopes resolve into immense clusters of stars. These *nebulæ*, as they are called, may be considered as so many milky ways, and some of them are supposed even "to outvie our Milky Way in grandeur." Above three thousand of these nebulæ have been discovered; and if only two thousand be supposed to be resolvable into starry groups, and to be as rich in stars at an average as our Milky Way, then we are presented with a scene which comprises 2000 times

20,191,000, or 40,382,000,000, that is, more than *forty thousand millions* of stars. And if we suppose, as formerly, fifty planetary globes to be connected with each, we have exhibited before us a prospect which includes 2,019,100,000,000, or two billions, nineteen thousand one hundred millions of worlds. Of such a *number* of bodies we can form no distinct conception, and much less can we form even a rude or approximate idea of the *grandeur* and *magnificence* which the whole of such a scene must display. Were we to suppose each of these bodies to pass in review before us *every minute*, it would require more than three millions, eight hundred and forty thousand years of unremitting observation before the whole could be contemplated even in this rapid manner. Were an hour's contemplation allotted to each, it would require two hundred and thirty millions, four hundred thousand years till all the series passed under review; and were we to suppose an intelligent being to remain fifty years in each world for the purpose of taking a more minute survey of its peculiar scenery and decorations, 100,955,000,000,000, or a hundred billions, nine hundred and fifty-five thousand millions of years would elapse before such a survey could be completed; a number of years which, to limited minds, seems to approximate to something like eternity itself.

Still, *all this countless assemblage of suns and worlds is not the universe.* Although we could range on the wings of a seraph through all this confluence of sidereal systems, it is more than probable that we should find ourselves standing only on the verge of creation, and that a boundless prospect, stretching towards infinity on every side, would still be presented to view; for we cannot suppose for a moment that the empire of Omnipotence terminates at the boundaries of human vision, even when assisted by the most powerful instruments. Other intelligences may have powers of vision capable of penetrating into space a hundred times farther than ours when assisted with all the improvements of art; but even such beings cannot be supposed to have penetrated to the uttermost boundaries of creation. Man in future ages, by the improvements of optical instruments, may be able to penetrate much farther into the remote regions of space than he has hitherto done, and may descry myriads of objects which have hitherto remained invisible in the unexplored regions of immensity. Ever since the invention of the telescope, one discovery has

followed another in almost regular succession. In proportion to the increase and activity of astronomical observers, and the improvement of the instruments of observation, the more remote spaces of creation have been explored, and new scenes of the universe laid open to human contemplation. And who shall set boundaries to the improvement and discoveries of future and more enlightened generations? Before the invention of the telescope, it would have been foolish to have asserted that no more stars existed than those which were visible to the naked eye; and after Galileo had discovered with his first telescopes hundreds of stars which were previously unknown, it would have been equally absurd to have maintained that the telescope would never be farther improved, and that no additional stars would afterward be discovered. It would be a position equally untenable to maintain that we shall never be able to descry objects in the heavens beyond the boundaries which we have hitherto explored, since science has only lately commenced its rapid progress, and since man is little more than just *beginning* to employ his powers in such investigations.

But, however extensive may be the discoveries of future ages, we may lay it down as an axiom, that neither man nor any other rank of finite beings will ever be able to penetrate to the farther boundaries of the creation. It would be presumptuous to suppose that a being like man—whose stature is comprehended within the extent of two yards, who vanishes from the sight at the distance of a German mile, whose whole habitation sinks into an invisible point at the distance of Jupiter, who resides on one of the smallest class of bodies in the universe, and whose powers of vision and of intellect are so limited—should be able to extend his views to the extreme limits of the empire of the Eternal, and to descry all the systems which are dispersed throughout the range of infinitude. It is more reasonable to believe that all that has yet been discovered of the operations of Omnipotence that lie within the boundaries of human vision, is but a very small portion of what actually exists within the limits of creation; that the two billions, and nineteen thousand millions of worlds which we have assumed as the scene of the visible universe, are only as a single star to the whole visible firmament, or even as a single grain of sand to all the myriads of particles which cover the seashores and the bed of the ocean, when compared with

what lies beyond the utmost range of mortal vision; for who can set bounds to infinitude, or to the operations of Him whose power is omnipotent, "whose ways are unsearchable," and "whose understanding is infinite?" All that we have yet discovered of creative existence, vast and magnificent as it appears, may be only a small corner of some mightier scheme which stretches throughout the length and breadth of immensity; of which the highest created intellect may have only a few faint glimpses, which will be gradually opening to view throughout the revolutions of eternity, and which will never be fully explored during all the periods of an interminable existence. What is seen and known of creation may be as nothing compared with what is unseen and unknown; and as the ages of eternity roll on, the empire of the Almighty may be gradually expanding in its extent, and receiving new additions to its glory and magnificence.

Hence we may conclude that there is no created being, even of the highest order of intelligences, that will ever be able to survey the whole scene of the universe. Of course, man, though destined to immortality, will never acquire a complete knowledge of the whole range of the Creator's operations, even during the endless existence which lies before him; for his faculties, however much expanded in that state, will be utterly inadequate to grasp a scene so boundless and august. It will be a part of his happiness that he will never be able to comprehend the universe; for at every period of his future existence he will still behold a boundless prospect stretched out before him, with new objects continually rising to view, in the contemplation of which, innumerable ages may roll away without the least apprehension of ever arriving at the termination of the scene. Were a superior intelligence ever to arrive at such a point, from that moment his happiness would be diminished, his love and adoration of the Supreme would wax faint and languid, and he would feel as if nothing new and transporting were to be added to his enjoyments throughout all the periods of his future existence. But the immensity of the universe, and the boundless nature of the dominions of "the King Eternal," will for ever prevent any such effects from being produced in the case of all virtuous and holy intelligences.

Besides the numerous bodies to which we have above alluded, there are several other objects which require to be con-

templated, in order to amplify our views of the visible universe. Those nebulous specks in the remote regions of the heavens termed *planetary nebulæ* have never yet been resolved into stars, and are, in all probability, bodies of a different nature from the Milky Way and other sidereal systems. Their magnitude is astonishing, since some of them would fill a cubical space equal to the diameter of the orbit of Uranus, which would contain 24,000,000,000,000,000,000,000,000,000, or twenty-four thousand quartilions of solid miles; that is, they are sixty-eight thousand millions of times larger than the sun. Such bodies present to our view *magnitudes* more astonishing than any others to be found within the range of the visible creation, and overwhelm the mind with wonder and amazement at what can possibly be their nature and destination. Several other nebulæ are no less wonderful, such as that in the constellation of Orion, which even surpasses in magnitude the dimensions now stated. It has been computed to be 2,200,000,000,000,000,000, or two trillions, two hundred thousand billions of times larger than the sun, a magnitude which we can scarcely suppose within the power of any finite being to grasp or to comprehend. For what end such huge masses of matter were created must remain a mystery to mortals so long as they are confined to this sublunary scene. Perhaps they are intended to give us a glimpse of objects and arrangements in the Divine economy altogether different from those we perceive in the planetary system and in the other parts of the sidereal heavens. But, whatever may be their ultimate destination, we may rest assured that they serve a purpose in the plan of the Divine administration worthy of their magnitude, and of the perfections of him by whom they were created. They were brought into existence by the same power which reared the other parts of creation; and as power is always accompanied with wisdom and goodness, they must have an ultimate reference to the accommodation and happiness of rational beings, under an economy, perhaps, widely different from that of the planetary and other systems.

Having taken a cursory view of the magnitudes of the numberless bodies scattered through the regions of space, let us now consider the *motions* which are incessantly going forward in every part of the universe; for all the myriads of globes and systems to which we have alluded are in rapid and perpetual motion; and we have no reason to believe that there

is a single quiescent body throughout the immensity of creation. We have here planets revolving around suns, planets revolving around planets, suns performing their revolutions around suns, suns revolving around the centres of sidereal systems, and, in all probability, every system of creation revolving round the centre and *Grand Mover* of the whole. The rate of these motions, in every known instance, is not less than several thousands of miles every hour, and, in many instances, thousands of miles in a minute. The motions which are found among the planetary globes appear, at first view, altogether astonishing, and almost to exceed belief, when we consider the enormous size of some of these bodies. That a globe a thousand times larger than our world should fly at the rate of thirty thousand miles an hour, and carry along with it a retinue of other mighty globes in its swift career, is an object that may well strike us with wonder and amazement. But the fixed stars—though to a common observer they appear exactly in the same positions with regard to each other—are found, in some instances, to be carried forward with motions far more rapid than even the bodies of the planetary system, though their magnitude is immensely superior. We have already seen that the star 61 Cygni, whose apparent motion is five seconds annually, and, consequently, imperceptible to a common observer, yet at the distance at which the star is known to be placed, this motion is equivalent to one thousand five hundred and fifty-two millions of miles in a year; four millions, two hundred and fifty-two thousand miles a day, and one hundred and seventy-seven thousand miles an hour. Other stars are found to move with velocities nearly similar, as μ Cassiopeia, which moves above three millions of miles a day, which is at the rate of two thousand one hundred and sixty miles every minute. These are motions altogether incomprehensible by human beings, especially when we take into consideration the enormous magnitude of the stars, some of which may be a thousand times larger than all the planets and comets belonging to our system. They display the amazing and uncontrollable ENERGIES OF OMNIPOTENCE, and afford a distinct source of admiration and astonishment in addition to all the other wonders of the universe. If, then, we would endeavour to attain a comprehensive idea of the motions going forward throughout the spaces of immensity, we must not only conceive of planets revolving around luminous centres, but of

suns revolving around suns; of suns and systems revolving around the centres of the nebulæ to which they respectively belong; of all the systems and nebulæ of the universe revolving in immense circumferences around the throne of the Eternal, the great centre of all worlds and beings; of each sun, and planet, and system, notwithstanding, pursuing a course of its own in different directions, and in numerous instances acted upon by different forces; in short, of the ten thousand times ten thousands of luminous and opaque globes, of every rank and order, within the circuit of creation; all performing their rapid but harmonious motions throughout every region of space, and without intermission, in obedience to the laws of their Creator.

Again, we cannot be supposed to have attained a comprehensive conception of the universe, without taking into account the sensitive and intellectual beings with which it is replenished. We ought never to consider the numerous orbs revolving throughout infinite space as mere masses of rude matter, arranged into systems merely to give a display of Almighty Power, but as means for accomplishing a higher and nobler end; the diffusion of happiness among countless orders of intelligent existence. And as this idea must necessarily be admitted, what a *countless* multitude of percipient beings must people the amplitudes of creation! On our globe there are supposed to be 800 millions of human beings; but it is capable of supporting twenty times that number, or sixteen thousand millions, if all its desolate wastes were cultivated and peopled. Besides man, there are numerous orders of other sensitive beings: there are at least 500 species of quadrupeds, 4000 species of birds, 3000 species of fishes, 700 species of reptiles, 50,000 species of insects, besides thousands which the microscope alone can enable us to perceive; at least sixty thousand species in all. If every species contain about 500 millions of individuals, then there will be no less than 30,000,000,000,000, or thirty billions of individuals belonging to all the different classes of sensitive existence on the surface of our globe.

If this earth, then, which ranks among the smaller globes of our system, contain such an immense number of living beings, what must be the number of sentient and intellectual existence in all the worlds to which we have alluded! We assumed, on certain data, that 2,019,100,000,000, or two billions

of worlds, may exist within the bounds of the visible universe; and, although no more beings should exist in each world, at an average, than on our globe, there would be the following number of living inhabitants in these worlds, 60,573,000,000,000,000,000,000,000; that is, sixty quartilions, five hundred and seventy-three thousand trillions, a number which transcends human conception. Among such a number of beings, what a variety of orders may exist, from the archangel and the seraph to the worm and the microscopic animalculum! What a diversity of ranks in the intellectual scale, from the point of the human faculties to the highest order of created beings, may be found throughout this immensity of existence! Some, perhaps, invested with faculties as far surpassing those of man as man surpasses in intellectual energy the worms of the dust, and still approximating nearer and nearer to the Deity. What a variety may exist among them in the form, organization, senses, and the movements of their corporeal vehicles! What a wonderful and interesting scene would their history disclose, were the whole series of events in the Divine administration towards them laid open to our view! the different periods in duration at which they were brought into existence; the special laws of social and moral order peculiar to each class of intelligences; the modes of improving the intellect, and the progress they have made in universal knowledge; the scenes of glory or of terror through which any particular classes of beings may have passed; the changes and revolutions that may await them; and the final destination to which they are appointed. These, and numerous other circumstances connected with the moral and intellectual universe, open to view a source of knowledge and a subject of sublime investigations which superior intellects might prosecute without intermission, with increasing admiration and rapture, and never arrive at the termination of their pursuits during all the periods of an endless existence.

Such is a summary view of the universe, in so far as its scenes lie open to our knowledge and investigation. The idea it presents is altogether overpowering to the human faculties, but it is nothing else than what we should naturally expect when we consider that the Being who formed it is self-existent and eternal; possessed of infinite wisdom, almighty power, and boundless goodness; and fills the infinity of space with his presence. It is like himself, boundless, and incom-

prehensible by finite minds; but exhibits to every order of intelligent beings a *sensible display* of "His Eternal Power and Godhead." Without the existence of such a universe, the infinite attributes of the Almighty could not be fully recognised and appreciated by his intelligent offspring. But here we behold, as in a mirror, the invisible perfections of the Divinity, "whom no man hath seen or can see," adumbrated, as it were, and rendered visible, in every part of creation, to the eyes of unnumbered intelligences; for there is no point of space in which a rational being could be placed, in which he would not find himself surrounded with sensible evidences and displays of the operations of an all-wise, an all-powerful, and incomprehensible Deity. "He has not left himself without a witness" to his existence, and his incessant energies, in any parts of his dominions, or to any of his creatures, wherever existing. "If we should ascend to heaven, he is there." If we should descend to the lower regions, he is there also to be seen in his operations. "If we take the wings of the morning," and fly along with the sun from east to west, and continue our course without intermission through regions of space invisible to mortal eye, "even there his hand would lead us, and his right hand uphold us." "Darkness" unfolds the grandeur of his operations and the glories of his nature, as well as the "light" of the orb of day. Though, on the wings of a seraph, we could fly in every direction through boundless space, we should everywhere find ourselves encompassed with his immensity, and with the manifestations of his presence and agency. Of such a Being, and of the universe he has formed, we may exclaim in the language of an inspired writer, "Oh the depth of the riches both of the wisdom and of the knowledge of God! How unsearchable are his operations, and his ways past finding out!"

Of this universe we can only form an approximate idea by comparing one small portion of it with another, and by allowing the mind to dwell for a considerable time on every scene we contemplate. We must first endeavour to acquire a comprehensive conception of the magnitude of the globe on which we dwell, and the numerous diversity of objects it contains; we must next stretch our view to some of the planetary globes, which are a thousand times greater in magnitude; and to such an orb as the sun, which fills a space thirteen hundred thousand times more expansive. Ranging through the whole

of the planetary system, we must fix our attention upon every particular scene and object, imagine ourselves traversing the hills, and plains, and immense regions of Jupiter, and surveying the expansive rings of Saturn in all their vast dimensions and rapid motions, till we have obtained the most ample idea which the mind can possibly grasp of the extent and grandeur of the planetary system. Leaving this vast system, and proceeding through boundless space till all its planets have entirely disappeared, and its sun has dwindled to the size of a small twinkling star, we must next survey the thousand stars that deck the visible firmament, every one of which must be considered as a SUN, accompanied with a system of planets no less spacious and august than ours. Continuing our course through depths of space immeasurable by human art, we must penetrate into the centre of the Milky Way, where we are surrounded by suns, not only in thousands, but in *millions*. Here the imagination must be left for a length of time, to expatiate in this amazing and magnificent scene, and try if it can form any faint idea of twenty millions of suns surrounded with a thousand millions of planets. Suppose one of these bodies to pass before the eye or the imagination every minute, it would require 1900 years before the whole could pass in review, and each produce a distinct impression as a separate object.

In a scene like this, the boldest imagination is overpowered and bewildered amid number and magnitude, and feels utterly incompetent to grasp the ten thousandth part of the overwhelming ideas presented before it. Winging our flight from the Milky Way, over unknown and immeasurable regions—regions where infinitude appears opening upon us in awful grandeur—we approach some of those immense starry clusters called NEBULÆ, every one of which may be considered as another milky way, with its ten thousands and millions of suns. Here the imagination must make a solemn pause, and take a wider stretch, and summon up all its powers, and force, and vigour; for here we have not merely *one* milky way, with its millions of stars, to contemplate, but *thousands*. If the immense splendour and amplitude of one milky way overwhelms us with amazement, and with an emotion almost approaching to terror, what an overpowering effect should two thousand of such scenes, which have already been discovered, produce upon minds so feeble and limited as ours! Such a scene not only displays to us, beyond every other, the incomprehensible

energies of Omnipotence, but seems to intimate that there are created beings existing in the universe endowed with powers of intelligence capable of forming a much more approximate idea of such objects than such beings as man, who may be considered as standing near the lowest point of the scale of intellectual existence. These "thrones and dominions, principalities and powers of Heaven," may be able to form a comprehensive perception of such a scene as the Milky Way, which baffles the utmost efforts of the human faculties.

Soaring beyond all these objects, we behold, as it were, a new universe in the immense magnitude of the planetary and other nebulæ, where separate stars have never been perceived; and, besides all these, there may be thousands, and ten thousands, and millions of opaque globes of prodigious size, existing throughout every region of the universe, and even in that portion of it which is within the limits of our inspection, the faintness of whose light prevents it from ever reaching our eyes. But, far beyond all such objects as those we have been contemplating, a boundless region exists, of which no human eye has yet caught a glimpse, and which no finite intelligence has ever explored. What scenes of power, of goodness, of grandeur, and magnificence may be displayed within this unapproachable and infinite expanse, neither men nor angels can describe, nor form the most rude conception. But we may rest assured that it is not an empty void, but displays the attributes of the Deity in a manner no less admirable and glorious, and perhaps much more so, than all the scenes of creation within the range of our vision. Here undoubtedly is that splendid region so frequently alluded to in the Scriptures, designated by the emphatic name, "THE HEAVEN OF HEAVENS," evidently importing that it is the most glorious and magnificent department of creation. Countless myriads of beings, standing at the highest point of the scale of intellect, and invested with faculties of which we have no conception, must inhabit those regions; for we are positively informed that "hosts" of intelligent beings reside in such abodes, and that "these hosts of the heaven of heavens worship God." But here our contemplations must terminate. Here imagination must drop its wing, since it can penetrate no farther into the dominions of Him who sits on the throne of immensity. Overwhelmed with a view of the magnificence of the universe, and of the perfections of its Almighty Author, we can only

fall prostrate in deep humility and adoration, and exclaim, "Great and marvellous are thy works, Lord God Almighty! Thou art worthy to receive glory, and honour, and power; for thou hast created all worlds, and for thy pleasure they are and were created."

I shall conclude this subject with the following remarks:

1. All the vast systems to which we have alluded are the workmanship of an Infinite and Eternal Being, and display the grandeur of his perfections. It is impossible that such an amazing universe, arranged with such exquisite order, and all the bodies it contains moving with such regular and rapid motions, could have formed itself, or been produced by the fortuitous concourse of atoms. The very surmise that such a thing was possible is one of the wildest hallucinations that ever entered the human mind. It is a first principle connected with the constitution of every intellectual nature, and without the admission of which there can be no reasoning, that there is a "connexion between cause and effect," and that "every effect must have a corresponding cause adequate to its production." The universe is an *effect*, the most sublime and glorious which the human mind can contemplate, and the natural and *necessary* conclusion which it almost instinctively draws is, that it is the production of an Eternal, Intelligent, and Almighty Being. This is a conclusion which has been deduced by men of all nations and in every period of the world. "There is no nation or people," says Cicero, "so barbarous and ignorant as not to acknowledge a powerful and Supreme Divinity."

It is as natural for the human understanding, in its original and unbiased state, when contemplating the frame of the universe, to infer the existence of a Deity, as it is the property of the eye to distinguish light and colours, and of the ear to distinguish sounds. The principle from which this conclusion is deduced is exactly the same as that by which, from the contemplation of a building, we infer a builder, and from the elegance and utility of every part of the structure we conclude that he was a wise and skilful architect; or that by which, from an inspection of a clock or watch, or any other piece of useful machinery, we infer not only the existence, but the qualities and attributes, of the contriver and artificer. The man who is incapable of at once deducing such conclusions ought to be regarded as destitute of the reasoning fac-

ulty; and if we thus necessarily infer the cause from the effect in the case of human art, can we for a moment hesitate to ascribe the production of this amazing universe which surrounds us to a Being of infinite knowledge, wisdom, and power, adequate to bring into existence such an immense and wonderful machine, and to preserve it in harmony from age to age, amid all its diversified and complicated movements? That ever a doubt was entertained on this subject is a plain proof that man has lost, in part, that light of reason and intelligence with which he was originally endued, or that he is sometimes urged on by depraved passions and a pride of singularity to utter sentiments which he does not sincerely believe. As Cicero long ago declared, "He who thinks that the admirable order of the celestial orbs, and their constancy and regularity, on which the conservation and good of all things depend, to be void of a mind that governs them, he himself deserves to be accounted void of a mind." It is "the *fool*" alone, in the strictest sense of the word, whatever may be his pretended learning, who dares to declare "there is no God."

And as the universe demonstrates the *existence*, so it displays the *attributes* of the Eternal. The manifestation of himself to numberless orders of intelligent beings must have been the great end intended in bringing the universe into existence. This manifestation is made chiefly in *actions*; in actions which display greatness, wisdom, and goodness beyond all bounds. His greatness appears from the immensity of *power* which the universe exhibits. The power necessary to move a single planet in its course far transcends human conception. What, then, must be the energy and extent of that power which set in motion and still upholds all the planets, worlds, and systems dispersed throughout the spaces of infinitude! The highest created intelligence must be utterly overwhelmed and confounded when it attempts to contemplate or to grasp an idea of omnipotence. His knowledge, wisdom, and unceasing agency are no less conspicuous in the arrangement and direction of everything that exists in heaven and on earth. As his presence pervades all space, so his agency is displayed in the minutest movement of every part of the vast whole. This great and incomprehensible Being moves every atom, expands every leaf of the forest, decks every flower, conveys the sap through the ramifications of

every tree, conducts every particle of vapour to its appointed place, directs every ray of light from the sun and stars, every breath of wind, every flash of lightning, every movement of the meanest worm, and every motion of the smallest microscopic animalculum; while at the same time he supports the planets in their courses, guides the comet in its eccentric career, regulates the movements of millions of resplendent systems, and presides in sovereign authority over unnumbered hosts of intelligent existence; directing all the mysterious powers of knowledge, virtue, and moral action to subserve the purposes of his will, and accomplish the ends of his moral government. In every department of this universe, likewise, his *goodness* is displayed to unnumbered orders of beings, sentient and intellectual; for all the powers of intelligence and action possessed by every creature in heaven and on earth, from the archangel to the worm, and all the happiness they now or ever will enjoy, are derived from him as the uncreated source of all felicity.

Under this glorious and stupendous Being we live and move; our comforts and enjoyments, while passing through this transitory scene, are wholly in his hands, and all our prospects of enjoyment beyond the range of our earthly career are dependant on his mercy and favour. His omnipotent arm supports us every moment; every breath we draw, every pulse that beats within us, every muscular power we exert, every sound that strikes our ears, and every ray of light that enters our eyeballs, is dependant on his sovereign will. All that we hope for beyond the limits of time and throughout the revolutions of eternity depends upon his power, his wisdom, his benevolence, and his promises. Were he to withhold the powers and agencies under which we now live and act, we could neither think nor speak, hear nor see, feel nor move; the whole assemblage of living beings in our world would be changed into immovable statues, and this earth transformed into a barren waste and an eternal solitude. To the service of this glorious Being all the powers and faculties with which he has endowed us ought to be unreservedly consecrated. As his highest glory and blessedness consist in bestowing benefits on his intelligent offspring, so we ought to be imitators of him in his boundless beneficence, by endeavouring to communicate happiness to all around us. "To do good, and to communicate, forget not; for with such sacrifices God is

well pleased." To him, as the "Father of our spirits and the former of our bodies," is due the highest degree of our love and gratitude; on him we ought to rely for every blessing, and humbly resign ourselves to his disposal under every event; for "all things are of God," and all are conducted with supreme and unerring wisdom and goodness to an end immortal and divine.

2. The immensity and magnificence of the universe, and the attributes of Deity it displays, are considerations which ought to be taken into account in all our views of religion. There is a class of men who, in prosecuting scientific pursuits, wish to discard everything that has a bearing on religion when deduced from the investigations of science, and can scarcely refrain from a sneer, when the arrangements in the economy of nature are traced to the agency of their All-wise and Omnipotent Creator; as if the objects which science professes to investigate had no relation to the views we ought to entertain of the Divinity, and ought never to be traced to their great first cause. On the other hand, there are many professed religionists who, from mistaken notions of piety, would set aside the study of the works of God, as having no connexion whatever with the exercises of piety and the business of religion, and as even injurious to their interests. Both these classes of men verge towards extremes which are equally inconsistent and dangerous. The amazing fact that creation consists of a countless number of magnificent systems and worlds beyond the comprehension of finite minds, ought not thus to be recklessly set aside in our views of God and of religion; for they are all the workmanship of ONE BEING, and they are connected together as parts of ONE grand system, of which the God we profess to worship is the supreme and universal governor. They present to the view of all intelligences the most glorious displays of his character and perfections, and consequently demand from us a corresponding sentiment of admiration and reverence, and a corresponding tribute of homage and adoration. Such enlarged prospects of the universe are therefore available for the loftiest purposes of religion and piety, and ought to enter as an element into all our views of the administration of the Almighty, and of that worship and obedience he requires from his rational offspring, unless we would be contented to render him a degree of hom-

age far inferior to that which the manifestation of his attributes demands.

God is known only by the manifestations which he makes of his character and perfections. The highest created intelligences can know nothing more of the Divinity than what is derived from the boundless universe he has presented to their view, the dispensations of his providence to certain orders of beings, and the special revelations he may occasionally vouchsafe, on certain emergencies, to particular worlds. Had man continued in primeval innocence, the contemplation of the vast creation around him, with all its diversified wonders and beneficent tendencies, would have led him to form correct views of the attributes of his Almighty Maker, and of the moral laws by which his conduct should be regulated; but it does not follow that, because the study of nature is now of itself an insufficient guide to the knowledge of the Creator and the enjoyment of eternal felicity, such studies are either to be thrown aside, or considered as of no importance in a religious point of view. To overlook the astonishing scene of the universe, or to view it with indifference, is virtually to "disregard the works of Jehovah, and to refuse to consider the operations of his hands." It is a violation of Christian duty, and implies a reflection on the character of the Deity for any one to imagine that he has nothing to do with God considered as manifested in the immensity of his works; for his word is pointed and explicit in directing the mind to such contemplations. "Hearken unto this; stand still, and consider the wonderful works of God." "Lift up thine eyes on high, and behold who hath created these orbs." "Remember that thou magnify his works which men behold." "Great and marvellous are thy works, Lord God Almighty! Thy saints shall speak of the glory of thy kingdom, and talk of thy power, to make known to the sons of men thy mighty operations and the glorious majesty of thy kingdom."

3. The Christian revelation, throughout all its departments, is not only consistent with the views we have taken of the universe, but affords direct evidence of the magnificence of creation, and of the myriads of beings with which it is peopled. Of this position we have exhibited some proofs in the remarks and illustrations contained in Chapter XVII., which show, at the same time, the harmony which subsists between the discoveries of revelation and the discoveries which have been

made in the system of nature. There is no other system of religion or pretended revelation that was ever propagated in the world to which such a characteristic belongs. If we examine the Mohammedan Koran, the Shasters of Bramah, the system of Confucius, the mythology of the Greeks and Romans, and every other pagan code of religion, we shall find interspersed throughout the whole of them numerous sentiments, opinions, and pretended facts at utter variance with the true system of nature, and to what are known to be the established laws of the universe. This is strikingly exemplified in the extravagant stories and descriptions contained in the pretended revelations of Mohammed, and the absurd notions respecting the creation contained in the sacred books of the Hindoos, which assert that the universe consists of seven heavens and seven worlds, which are all at a future period to be absorbed into God, with many other absurdities. In opposition to all such foolish and absurd opinions, the inspired writings, when properly understood, and rationally interpreted according to the rules of just criticism, are uniformly found to be perfectly consistent with the discoveries of science, and the facts which are found to exist in the system of the universe; and this correspondence and harmony ought to be considered as a strong presumptive evidence that the revelations of Scripture and the scenes of the material universe proceed from the same All-wise and Omnipotent Author.

CHAPTER XX.

ON COMETS.

As this class of the celestial bodies forms a part of the solar system, it might have been more appropriate to have introduced the subject into our volume entitled "Celestial Scenery," which has for its principal object a description of the bodies connected with that system; but as that work swelled to a greater size than was at first foreseen, it was judged expedient to postpone the consideration of comets to the present volume. As our knowledge of these bodies, however, is very

limited, and no discoveries have yet been made which might lead us to form a decisive opinion of their nature and destination, I shall content myself with giving a brief detail of some of the leading facts which have been ascertained respecting them.

The word *comet* literally signifies a *hairy star;* because such bodies are generally accompanied with a nebulosity or train, which has the appearance of luminous hair. The luminous point near the centre of a comet, which is most brilliant, is called the *nucleus.* The haze or nebulosity which surrounds the nucleus is called the hair, and sometimes the *envelope;* and the nucleus and hair combined constitute what is usually termed the *head* of the comet. The luminous train, extending sometimes to a great distance from the head, is called the *tail* of the comet. These bodies have occasionally appeared in the heavens in all ages. The ancients were divided in their opinions respecting them; some considering them as wandering stars, others as meteors kindled in the atmosphere of the earth, subsisting for a time, and then dissipated; and others viewed them as prodigies indicating wars, famines, inundations, or pestilences. Aristotle, who believed that the heavens were incorruptible and unchangeable, maintained that comets were generated when they first made their appearance, and were destroyed when they ceased to be visible, and, consequently, that they could not be reckoned to belong to the heavenly bodies, but were only meteors or exhalations raised into the upper regions of the air, where they blazed for a while, and disappeared when the matter of which they were formed was consumed. And as the opinions of this ancient sage had a powerful influence on the philosophers and astronomers of later times, as his assertions were frequently regarded as little short of demonstrations, few persons had the boldness and independence of mind to call in question the positions he maintained on any subject discussed in his writings.

It was not before the time of the celebrated astronomer Tycho Brahe that the nature of comets began to be a little understood, and that they were considered as moving in the planetary regions. This astronomer observed with great diligence the famous comet which appeared in 1577; and, from many accurate observations during the time of its appearance, found that it had no sensible diurnal parallax, and therefore

was not only far above the limits of our atmosphere, but beyond the orbit of the moon itself. Its motions were likewise particularly observed by Hagecius, at Prague, in Bohemia, at the same time that they were observed by Tycho, at Uraniburg. These two places differ six degrees in latitude, and are nearly under the same meridian, and both measured the distance of the comet from the same star, which was in the same vertical circle with the comet; yet both observers found their distances the same, and, consequently, they both viewed the comet in the same point of the heavens, which could not have happened unless the comet had been in a higher region than the moon. After Tycho, Kepler had an opportunity of making observations on the comets which appeared in 1607 and 1618, and from all his observations he deduced this conclusion, "that comets move freely through the planetary orbs." From this period comets began to be more accurately observed, and to be considered as constituent parts of the solar system; and at length the illustrious Newton demonstrated that their motions are performed in long ellipses, having the sun in one of their foci.

Before proceeding to inquire into the nature and physical constitution of these bodies, I shall present the reader with

A brief sketch of the history of the most remarkable comets which have appeared in modern times.

One of the most remarkable comets which have appeared in modern times is that which made its appearance towards the close of the year 1680, and which was particularly observed by most of the astronomers of Europe. This comet, according to the accounts given by the astronomers of that period, appeared to descend from the distant regions of space with a prodigious velocity, almost perpendicular to the sun, and ascended again in the same manner from that luminary with a velocity retarded as it had before been accelerated. It was observed, particularly at Paris and Greenwich, by Cassini and Flamstead, by whom it was seen in the morning from the 4th to the 26th of November, 1680, in its descent towards the sun; and after it had passed its *perihelion*,* in the even-

* The *perihelion* is that point in the orbit of any planet or comet which is nearest to the sun. It is also called the *lower apsis*. The *aphelion* is that point in the orbit which is farthest from the sun; called, also, the *higher apsis*.

ing, from the 12th of December to the 9th of March, 1681. The many exact observations made on this comet enabled Sir I. Newton to discover that so much of its orbit as could be traced by the motion of the comet, while it was visible, was, as to sense, a *parabola*, having the sun in its focus, and that it was one and the same comet that was seen all that time. This comet was remarkable for its very near approach to the sun. At its perihelion it was not above a sixth part of the sun's diameter from its surface; that is, about 146,000 miles from the surface of that luminary, and 584,000 from its centre. According to Sir Isaac Newton, the velocity of this comet when nearest the sun was 880,000 miles an hour. On taking its perihelion distance, as given by M. Pingré, Mr. Squire found, by two different calculations, that its velocity in its perihelion was no less than 1,240,000 miles an hour! This velocity was so great that, if continued, it would have carried it through 124 degrees in an hour; but its actual hourly motion during that interval, before and after it passed the perihelion, was 81 degrees, 47 minutes. At this period, the diameter of the sun, as seen from the comet, must have subtended an angle of more than a hundred degrees, which must nearly have filled its whole hemisphere.

From Dr. Halley's determination of its orbit, it appears that when in its aphelion, or greatest distance from the sun, it cannot be less than 13,000,000,000, or thirteen thousand millions of miles distant from that luminary; that is, seven times the distance of Uranus. According to the same astronomer, this comet, in passing through its southern node, came within the length of the sun's semidiameter of the orbit of the earth, that is, within 440,000 miles; and he remarks, "had the earth been then in that part of its orbit nearest that node of the comet, their mutual gravitation must have caused a change in the plane of the earth's orbit and in the length of our year; and if so large a body with so rapid a motion were to strike the earth, a thing by no means impossible, the shock might reduce this beautiful frame to its original chaos." Modern observations, however, render such deductions somewhat improbable. The *period* of this comet is supposed to be about 575 years. It is conjectured that it is the same comet which appeared in 1106, in the reign of Henry I., that was seen during the consulate of Lampadius and Orestes, about the year 531, and in the forty-fourth year before Christ, in which year

Julius Cæsar was murdered. Its nucleus was computed to be about ten times as large as the moon. Its tail extended over a space of seventy degrees in extent.

This is the comet, to the near approach of which to the earth Mr. Whiston attributed the universal deluge in the time of Noah. His opinion was, that the earth, passing through the atmosphere of the comet, attracted from it a great part of the water of the flood; that the nearness of the comet raised a great tide in the subterranean waters; that this could not be done without making fissures or cracks in the outer crust of the earth; that through these fissures the subterraneous waters were forced; that along with the water much slime or mud would rise, which, after the subsiding of the water partly into the fissures and partly into the lower parts of the earth to form the sea, would cover over to a considerable depth the antediluvian earth; and thus he accounts for trees and bones of animals being found at very great depths in the earth. The same comet, he supposed, when coming near the earth, after being heated to an immense degree in its perihelion, would be the instrumental cause of that great catastrophe, the general conflagration. Modern geological researches, however, render all such hypotheses utterly untenable.

2. Another comet which has obtained a certain degree of celebrity is that which appeared in 1682, and is usually distinguished by the name of *Halley's comet.* This comet appeared with considerable splendour, and exhibited a tail thirty degrees in length. On calculating its elements from its perihelion passage, Dr. Halley was led to conclude that it was identical with the great comets which appeared in 1456, 1531, and 1607, whose elements he had also ascertained. The intervals between these periods being about seventy-five or seventy-six years, he was led to conclude that this was the period of the revolution of the comet, and ventured to predict that it would again return about the latter part of the year 1758. As this was the first comet whose return had been predicted, when the time of its expected appearance approached, astronomers became anxious to ascertain whether the attraction of the larger planets, Jupiter and Saturn, might not interfere with its orbitual motion, and prevent it from arriving at its perihelion so soon as the time predicted. Clairaut, an eminent French mathematician, after many intricate and laborious calculations in reference to the subject, concluded that the attraction of

Saturn would lengthen the period 100 days, and the action of Jupiter 518, making in all 618 days, by which the expected return would happen later than if no such influence had taken place; so that, instead of the period being 74 years, 323 days, it ought to be 76 years, 211 days; and as the comet passed its perihelion on September 14, 1682, it ought to reach the same point on April 13, 1759. These calculations were read beford the Academy of Sciences, on the 14th of November, 1758; but Clairaut gave notice that, being pressed for time, he had neglected in his calculations small values, which collectively might amount to about thirty days in the seventy-six years. These predictions were accordingly verified; for the comet appeared about the end of December, 1758, and arrived at its perihelion on the 13th of March, 1759, only thirty days before the time fixed by the calculations of Clairaut, who, upon repeating the process by which he had arrived at the result, reduced this error to nineteen days. The same comet again made its appearance, according to prediction, in 1835, of which a particular account will be given in the sequel.

3. Another remarkable comet made its appearance in 1744, which excited a considerable degree of attention. It was first seen at Lausanne, in Switzerland, December 13, 1743; from that period it increased in brightness and magnitude as it approached nearer the sun. On the evening of January 23, 1744, it appeared exceedingly bright and distinct, and the diameter of its nucleus was nearly equal to that of Jupiter. Its tail then extended above 16 degrees from its body, and was supposed to be about 23 millions of miles in length. On the 11th of February, the nucleus, which had before been always round, appeared oblong in the direction of the tail, and seemed divided into two parts by a black stroke in the middle. One of the parts had a sort of beard, brighter than the tail; this beard was surrounded by two unequal dark strokes, that separated the beard from the hair of the comet: these odd phenomena disappeared the next day, and nothing was seen but irregular obscure spaces like smoke in the middle of the tail, and the head resumed its natural form. On the 15th of February the tail was divided into two branches, the eastern about 8 degrees long, the western 24. On the 23d the tail began to be bent. It showed no tail till it was as near the sun as the orbit of Mars, and it increased in length as it approached nearer that luminary. At its greatest length it was

computed to equal a third part of the distance of the earth from the sun.* This was one of the most brilliant comets that had appeared since that of 1680. Its tail was visible for a long time after its body was hid under the horizon: it extended 20 or 30 degrees above the horizon, two hours before sunrise.

4. In the month of June, 1770, Messier discovered a comet, the motions of which appeared to be involved in a considerable degree of mystery. The comet continued visible for a long time. Lexell ascertained, from observation, that it described an ellipse around the sun, of which the greater axis was only three times the diameter of the earth's orbit, which corresponds with a revolution of five and a half years. It was therefore expected that it would again frequently make its appearance; but it has never since been visible, although it made a pretty brilliant appearance in 1770. The National Institute of France, not many years ago, requested M. Burckhardt to repeat all the calculations with the utmost care; and the result of his labour has been a complete confirmation of the elements obtained by Lexell. What has become of this comet it is difficult to conjecture. Its aphelion, or greatest distance from the sun, was reckoned to be not far beyond the orbit of Jupiter, and that it approached as near to the earth as the moon, and ought to have appeared twelve times since the year 1770. M. Arago attempts to solve the difficulty by affirming that its orbit was then totally different from that which it has since pursued; that its passage to the point of perihelion in 1776, when it was expected, took place by day, and, before the following return, the form of the orbit was so altered that, had the comet been visible from the earth, it would not have been recognised; that, before 1767, during the whole progress of its revolutions, its shortest distance from the sun was 199,000,000 leagues, and that, after 1779, the minimum distance became 131,000,000 leagues, which was still too far removed for the comet to be perceptible from the earth. Sir David Brewster attempts to account for its disappearance by supposing that it must have been attracted by one of the planets whose orbit it crossed, and must have imparted to it its nebulous mass; and that it is probable the comet passed near Ceres and Pallas, and imparted to them those immense

* Memoirs of the Academy of Sciences for 1744.

atmospheres which distinguish them from all the other planets. Whether any of these opinions be tenable and sufficient to solve the difficulty, is left entirely with the reader to determine.

5. Another comet, which has engaged the particular attention of astronomers during the last twenty years, is distinguished from all preceding comets by the *shortness of its periodic revolution.* It is usually denominated *Encke's comet,* so called from Professor Encke, of Berlin, who first ascertained its periodical return. It was discovered at Marseilles, on the 26th November, 1818, by M. Pons, and its parabolic elements were presented to the Board of Longitude, at Paris, by M. Bouvard, on the 13th of January, 1819. It was immediately remarked that the result of Bouvard's calculations was too similar to the elements of a comet which appeared in 1805, not to consider that and the one of 1818 as the same body; and M. Encke soon after established, by incontestable calculations, that this comet took only about 1200 days, or three years and three tenths, to travel through the whole extent of its elliptic orbit. This was considered as a very extraordinary result, as an opinion had previously prevailed that the period of the revolution of a comet must *necessarily* be long. It now appears that this comet was first seen by Messier and Mechain in 1786; afterward by Miss Herschel in 1795; and its subsequent returns were observed by different astronomers in 1805 and 1819, all of whom, at those periods, supposed that the four comets were four different bodies The elements of this comet, and the short period of its revolution, are now incontrovertibly established; for its reappearance in the southern hemisphere in June, 1822, took place very nearly in the positions previously calculated. The agreement was not less remarkable in 1825; and in 1828, the third period of its announced return, it occupied the places assigned to it by Encke the year preceding. It likewise appeared in 1832, 1835, and 1838.

This comet is very small; its light is feeble; it has no tail; it is invisible to the naked eye, except in very favourable circumstances, but may be seen with a small magnifying power. It revolves in an elliptical orbit of considerable eccentricity, having an inclination to the plane of the ecliptic of 13⅓ degrees. On comparing the intervals between the successive perihelion passages of this comet, a singular fact

has been elicited, namely, that its periods are continually diminishing, and its mean distance from the sun shortening by slow but regular degrees. This is supposed by M. Encke to be produced by a resistance experienced by the comet from a very rare ethereal medium pervading the regions through which it moves; since such resistance, by diminishing also its actual velocity, would diminish also its centrifugal force, and thus give the sun more power over it to draw it nearer. It is therefore the opinion of Sir J. Herschel, that "it will probably fall ultimately into the sun, should it not first be dissipated altogether, a thing no way improbable, when the lightness of its materials is considered, and which seems authorized by the observed fact of its having been less and less conspicuous at each reappearance." The acceleration of this comet is about two days in each revolution; and the frequent opportunities of observation which will occur, in consequence of the shortness of its period, may lead to new and interesting conclusions in relation to the nature of these bodies.

6. Besides the above, another periodical comet has lately been discovered, which is distinguished by the name of *Biela's*, and sometimes *Gambart's comet*. This comet was perceived at Johanisberg, on the 27th Feb., 1826, by M. Biela; and by M. Gambart, at Marseilles, ten days afterward. Gambart, without delay, calculated its parabolic elements from his own observations, and by inspecting a general table of comets, he recognised that it was not its first appearance, but that it had been already observed in 1789 and 1795. Messrs. Clausen and Gambart undertook the computation of the comet's revolution, and found, each of them nearly at the same time, that the new comet made its entire revolution round the sun in a period of about seven years. It was afterward found, more accurately, to be 2460 days, or nearly 6¾ years. M. Damoiseau calculated the perturbations of this comet, and predicted that it would cross the plane of the earth's orbit on the 29th of October, 1832, *a little before midnight*, at a point about 18,480 miles within the orbit of the earth. According to this prediction, the comet actually made its appearance in 1832, about the time now specified. Its next appearance was calculated to happen in 1839; and it was reckoned that it would arrive at its perihelion on the 23d July of that year.

The predicted appearance of this comet in 1832 seems to have produced considerable alarm, particularly in France.

Some German journalists predicted that it would cross the earth's orbit near the point at which the earth would be at the time, and cause the destruction of our globe. Such was the degree of alarm excited on this occasion, that M. G * * *, a professor in Paris, put the question to the Academy of Sciences, whether it did not consider itself bound in duty to refute, as speedily as possible, this assertion. "Popular terrors," he observed, "are productive of serious consequences. Several members of the Academy may still remember the accidents and disorders which followed a similar threat, imprudently communicated to the Academy by M. de Lalande, in May, 1773. Persons of weak minds died of fright, and women miscarried. There were not wanting people who knew too well the art of turning to their advantage the alarm inspired by the approaching comet, and *places in paradise were sold at a very high rate.* The announcement of the comet of 1832 may produce similar effects, unless the authority of the Academy apply a prompt remedy; and this salutary intervention is at this moment implored by many benevolent persons." It was supposed by some, that if any disturbing cause should delay the arrival of the comet for some months, the earth must pass directly through its head.

In order to dispel such fears, and to illustrate the nature of these bodies, M. Arago published an excellent and popular treatise on comets in the "*Annuaire*" of 1832. He showed that the result of the calculation was, that the passage of the comet ought to proceed *a little within our orbit*, and at a distance from that curve, which is equal to *four terrestrial radii and two thirds*, or about 37,000 miles; that on the 29th October, 1832, *a portion of the earth's orbit* might be included within the nebulosity of the comet; but that the earth would not arrive *at the same point* of its orbit till the morning of the 30th November, or more than a month afterward; and, consequently, that the earth would be more than twenty millions of French leagues (or fifty millions of British miles) distant from the comet. He adds, that "if the comet, instead of crossing the plane of the ecliptic on the 29th October, had not arrived there till the morning of the 30th November, it would have undoubtedly mingled its atmosphere with ours, and perhaps even have struck us!" The earth is considered in more danger, if danger there be, from this comet and that of Encke than from any other. Encke's comet crosses the orbit of the

earth sixty times in the course of a century, and there is certainly a *possibility* that it might come into collision with the earth, but the probability of its doing so is very small; and, besides, this comet and that of Gambart are so extremely rare, that little danger is to be apprehended, even although a contact were to take place. Gambart's is a small, insignificant comet, without a tail, or any appearance whatever of a solid nucleus, and is not distinguishable by the naked eye.

7. *The comet of* 1807.—This was the first comet on which I had an opportunity of making observations. My first observation was on the evening of October the 8th, 1807, a little after sunset, when it appeared in a northwesterly direction, not far distant from Arcturus, which was then only a little above the horizon. To the naked eye it appeared somewhat like a dim nebulous star of the second magnitude, with a beam of light on one side of it. Through a telescope, its tail presented a pretty brilliant appearance, and occupied a space of considerable more than a degree in length. The coma seemed to have a roundish appearance, and appeared more indistinct as the magnifying power was increased. When viewed with an achromatic telescope of thirty-one inches focal distance, and a power of thirty, it presented a very distinct and beautiful appearance, and the nucleus, coma, and tail nearly filled the field of view. When a power of sixty was applied, it was much more indistinct than with the former power, and in all the subsequent observations the lower power was generally preferred. In the course of five or six weeks, or about the middle of November, it disappeared to the naked eye. I traced it with the telescope, as often as the weather would permit, for two or three months after it had become invisible to the unassisted sight, and found that its apparent motion was pretty rapid, and towards the northeast. About the middle of January, 1808, at eleven P.M., it appeared in a direction northeast by north; and at this time it appeared through the telescope like a small nebulous star, or like those species of comets called *bearded* comets, having no trace of anything similar to a tail. The last time I saw it was about the end of January, when it was still distinctly visible, like a nebulous star; but cloudy weather for nearly a fortnight prevented any farther observations, and I saw it no more. On the evening in which I had the last peep of it, I detected another comet within eight or ten degrees of it, which appeared like a star of

the third magnitude, and exhibited a pretty brilliant appearance through the telescope. It had no tail, like the former comet, but appeared surrounded with radiant hairs like the *glory* which painters represent around the head of our Saviour. It continued visible for several weeks; but I have not seen any particular notices of this second comet, or any special observations on it, which have been recorded by astronomers.

This comet appears to have been first noticed by Herschel and Schroeter about the 4th of October, 1807, who continued their observations upon it for several months. According to Schroeter's observations and estimates, the diameter of the nucleus of this comet was about 4600 miles, or nearly the size of the planet Mars, and appeared to be of considerable density; the diameter of its coma 120,000 miles, but liable, at different times, to variations of increase and decrease; and its rate of motion, at certain periods, 1,333,380 miles a day, or 55,557 miles an hour. Its tail was divided in a very unusual manner into two separate branches; the north side continued much brighter and better defined than the other, and was also invariably convex, while the other side was concave. But what was deemed most remarkable was the variation in length and the *coruscations* of the tail. Something like coruscation had been observed by the naked eye in the case of preceding comets, and such phenomena appear to have been confirmed by the observations of Schroeter. In less than one second, streamers shot forth to two and a half degrees in length; they as rapidly disappeared and issued out again, sometimes in portions, and interrupted like our northern lights. Afterward the tail varied both in length and breadth, and in some of the observations the streamers shot from the whole expanded end of the tail, sometimes here, sometimes there, in an instant, two and a half degrees long, so that within a single second they must have shot out a distance of 4,600,000 miles. Their light was also sometimes whiter and clearer at the end than at the base, as is occasionally seen in the northern lights. Some have objected to the extreme rapidity of the streamers as here stated, but the fact of coruscations having been seen appears to be confirmed by the observations of this celebrated and accurate observer. The observations of Herschel on this comet differ in some respects from those of Schroeter, particularly in the estimate he makes of the size of the nucleus, which he reckons to be considerably smaller than what has been stated above.

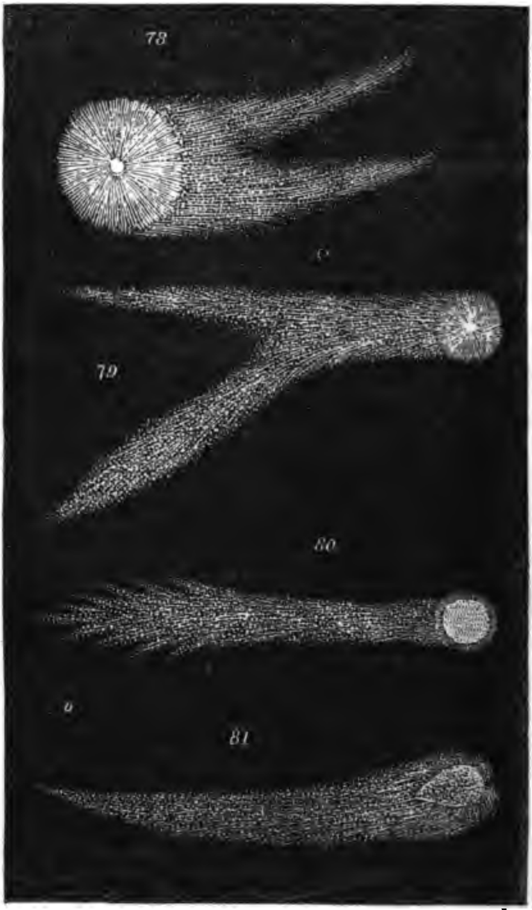

78
79
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Fig. 78 is a view of this comet, as seen on the night of October 21st by Schroeter. Fig. 79 is a view of the same comet, as seen by Bessel, October 22d, at eight in the evening; both which exhibit its divided tail.

8. The most remarkable comet which has appeared in modern times, since that of 1680, was *the comet of* 1811. About the beginning of September in that year, about eight or nine in the evening, as I was taking a random sweep with my telescope over the northwestern quarter of the heavens, an uncommon object appeared to pass rapidly across the field of view, which, on examination, appeared to be a splendid comet. Not having heard of the appearance of any such body at that time, I was led to imagine that I had fortunately got the first peep of this illustrious stranger; but I afterward learned from the public prints that it had been seen a day or two before by Mr. Veitch, in the neighbourhood of Kelso, who appears to have been the first that observed it in Britain. This comet appeared with peculiar splendour, and was visible, even to the naked eye, for more than three months in succession, and excited universal attention. It afforded to astronomers more opportunities for observation of its physical aspect and constitution, and for determining the elements of its orbit, than almost any other comet that had previously appeared. The two celebrated observers, Herschel and Schroeter, made numerous and very particular observations on the phenomena and motions of this comet, which were continued every clear evening for the space of nearly five months. Some of these observations, along with the remarks and deductions connected with them, are extremely interesting to the astronomical observer; but my limits will permit only a statement of the general results.

Some of the results deduced by Schroeter are the following: That the central globe of light, or what he calls the nucleus, was 50,000 miles in diameter, or nearly six and a half times the diameter of the earth, which he deduced from the mean of twenty-seven measurements, which gave 1′ 49″ as the mean angular diameter of the body; that this great body was in all probability chiefly fluid, though its central parts might consist of denser substances; and that there was reason to believe that it shone with its own native light. The *coma* was extremely rarefied in comparison with the nucleus, resembling a very faint whitish light, scattered in separate portions. It

was divided into two; one immediately encompassing the nucleus, the other of a more faint and grayish light, sweeping round it at a distance, and forming the double tail which the comet presented. The *train*, or *head veil*, as he terms it, swept round the nucleus at a distance equal to its breadth, and appeared as unconnected as the ring of Saturn with its body, and which sometimes appeared darker than the open sky. The diameter of this exterior part of the head was 34′ 15″, or about 947,000 miles, which is larger than the diameter of the sun, and which he thinks must have formed a hollow cone around the nucleus, and which he thought indicated a force of a repulsive nature residing in the nucleus. Between the 4th and 6th of December a great revolution took place; the rarefied nebulous matter, which had for three months been so unusually repelled from the nucleus on every side, to a distance of about one fifth of the diameter of the head, or 190,000 miles, was again attracted to it, affording an incontrovertible proof of physical action upon a great scale, arising doubtless from the same causes which produce the other phenomena of nature. The double tail of this comet was exceeding faint compared with the nucleus and coma. On the 23d of October, it extended fully eighteen degrees, notwithstanding its oblique position, the angle at the sun being then 61° 23′; at the earth, 69°; and at the comet, 49° 37′. Had it been viewed at right angles, it would have subtended an angle of 36° 36′, equivalent to more than 60,000,000 of miles, which is more than half the distance from the earth to the sun. *Coruscations*, similar to those which appeared in the tail of the comet of 1807, were likewise perceived, particularly on October the 16th, when a small tail instantaneously appeared, then vanished, and reappeared, which was in length equal to three times the diameter of the comet's head, or 2,373,000 miles. Other displays of the same kind took place on the 7th of November and the 18th of December. These facts, of the reality of which Schroeter entertained not the least doubt, must be considered as very curious and extraordinary phenomena.*

* Having referred, on various occasions, to the observations of that indefatigable astronomer, *Schroeter*, of Lilienthal, it may not be uninteresting to some readers to insert the account of the losses he sustained by the burning and plunder of his observatory, as expressed in his own pathetic language:

"At length, after the most touching afflictions of mortality, I once more awoke in my temple consecrated to the Eternal Godhead, and am again

Herschel's observations nearly agree with those of Schroeter, excepting that he estimates the diameter of the nucleus as very much smaller than what is stated above. He estimates the *greatest length* of the tail, as seen on the 15th of October, to have been 100,000,000, or a hundred millions of miles, which consequently extended over a space larger than that which intervenes between the earth and the sun; and its *breadth*, as deduced from the observations of October the 12th, nearly fifteen millions of miles. He calculated its distance, when nearest the earth, to be about 113 millions of miles. He concluded that the solid matter of the comet was spherical, that it shone in part by its own native light, and that it probably had a rotation round its axis. From the most accurate observations of the motion of this comet, its period of revolution has been calculated to exceed 3000 years. Bessel computes it at 3383 years; and several other astronomers conceive its period to be considerably longer, even exceeding 4000 years.

9. *Reappearance of Halley's comet in* 1835.—The return of this comet was calculated by Messrs. Damoiseau and Pontecoulant; the former of whom calculated its return to the

able, after a total derangement of my affairs, to edit these collections concerning the great comet of 1811. Through the most barbarous fury, in consequence of an equally barbarous decision, the whole innocent soft vale of Lilies [the signification of the name Lilienthal, where his observatory was situated] was burned to the ground, without any previous examination. They likewise burned down the royal government buildings. I lost my whole moveable property, and, what was more sensibly felt by me, among it, with a considerable loss also to the booksellers of Europe, the sole copy of the whole of my works and writings deposited in the government house. Even my observatory, preserved by Providence from the fire, was a few days afterward broken into, plundered, and shamefully thrown into confusion by demolishing the clocks, breaking off the finders from the instruments, and carrying off the smaller instruments. Previously, indeed, having been removed from my post, my income had gradually become so very straitened, I was obliged to forego all but the most necessary outlays, and to give myself up to a scientific slumber. Under the endurance of these troubles, all my scientific patrons and friends will doubtless, as far as possible, excuse me, if, through melancholy, and on account of the extraordinary high rate of postage, I have been compelled to put out of sight so many obligations of courtesy; for to the present time everything is so straitened with me, that my observatory, from want of time and heavy expenses, is for the most part a confusion.

"JOH. HIERONYM. SCHROETER.

"*Lilienthal, Jan.* 22, 1815."

Schroeter did not long survive the calamity alluded to above. He died on the 29th of August, 1816, in the 71st year of his age.

perihelion on the 4th, and the latter on the 7th of November, 1835, and it actually arrived at that point only a few days after these periods, namely, on the 16th of November. It was first seen on the Continent in the month of August that year, but does not appear to have been noticed in the northern parts of Britain till more than a month afterward. Its expected reappearance excited universal attention throughout Europe. Soon after the middle of September, as I was taking a sweep with a two-feet telescope over the northeastern quarter of the heavens, near the point where I expected its appearance, I happened to fix my eye on this long-expected visiter, which appeared very small and obscure. I immediately directed an excellent three and a half feet achromatic telescope, with a diagonal eyepiece, magnifying about thirty-four times, to the comet, when it was distinctly seen, and appeared of a considerable diameter, but still somewhat hazy and obscure. I afterward applied a power of forty-five, and another of ninety-five; but it was seen most distinctly with the lower power. With ninety-five it appeared extremely obscure, and nearly of the apparent size of the moon.* There appeared at this time nothing like a tail, but the central part was much more luminous than the other portions of the comet, and presented something like the appearance of a star of the third or fourth magnitude surrounded with a haze. In some of the views I took of this object, the luminous part or nucleus appeared to be considerably nearer one side than another. At this period, and for a week or ten days afterward, the comet was altogether invisible to the naked eye. Many subsequent observations were made, and published in the provincial newspapers, but which my present limits prevent me from inserting.

After the comet became visible to the naked eye, the tail began to appear, and increased in length as it approached its perihelion, and its utmost extent was estimated to be above thirty degrees in length. On the 13th of October, according to the observations of Arago, a luminous sector was visible in its head; on the day following this sector had disappeared, and a more brilliant one, and of greater longitudinal extent, was formed in another place. This second sector was ob-

* In viewing comets, telescopes with large apertures and comparatively low magnifying powers should generally be used, as the faint light emitted by comets, whether it be inherent or reflected, will not permit the use of so high magnifying powers as may be applied to the planets.

served on the 17th, when it appeared less bright; and on the 18th its weakness had decidedly increased. The comet was concealed till the 21st, but on that day three distinct sectors were visible in the nebulosity. On the 23d, all traces of these sectors had disappeared; the nucleus, which had previously been brilliant and well-defined, having become so large and diffuse that the observer could scarcely believe in the reality of such a sudden and important alteration, till he satisfied himself that the appearance was not occasioned by moisture on the glasses of his instrument. It appears, likewise, that one of these luminous fans or sectors was observed by Sir J. Herschel, at the Cape of Good Hope, after the comet had passed its perihelion. The nebulosity of this comet appears to have increased in magnitude as it approached the sun, but its changes were sometimes unaccountably rapid. On one occasion it was observed to become obscure and enlarged in the course of a few hours, though a little before its nucleus was clear and well defined. On the 11th of October the Rev. T. W. Webb, and two other observers, observed *coruscations* in the tail. On that evening, at $7^h\ 30'$, the tail was very conspicuous, extending between κ and λ Draconis, and evidently fluctuated, or rather coruscated, in length, being occasionally short, and then stretching, in the twinkling of an eye, to its full extent, which was at least equal to ten degrees. Its changes were extremely similar to the kindling and fading of a very faint streamer of the Aurora Borealis.

"The influence of the ethereal medium on the motion of Halley's comet will be known after another revolution, and future astronomers will learn, by the accuracy of its returns, whether it has met with any unknown cause of disturbance in its distant journey. Undiscovered planets beyond the visible boundary of our system may change its path and the period of its revolution, and thus may indirectly reveal to us their existence, and even their physical nature and orbit. The secrets of the yet more distant heavens may be disclosed to future generations by comets which penetrate still farther into space, such as that of 1763, which, if any faith may be placed in the computation, goes nearly forty-three times farther from the sun than Halley's does, and shows that the sun's attraction is powerful enough, at the distance of 144,600 millions of miles, to recall the comet to its perihelion. The periods of some comets are said to be many thousand years, and even

the average time of the revolution of comets generally is about a thousand years; which proves that the sun's gravitating force extends very far. La Place estimates that the solar attraction is felt throughout a sphere whose radius is a hundred millions of times greater than the distance of the earth from the sun." "The orbit of Halley's comet is four times longer than it is broad; its length is about 3420 millions of miles, about thirty-six times the mean distance of the earth from the sun. At its perihelion it comes within fifty-seven millions of miles of the sun, and at its aphelion it is sixty times more distant. On account of this extensive range, it must experience 3600 times more light when nearest to the sun than in the most remote point of its orbit. In the one position the sun will seem to be four times larger than he appears to us, and at the other he will not be apparently larger than a star."*

The appearance of this comet, so near the time predicted by astronomers, and in positions so nearly agreeing with those which were previously calculated, is a clear proof of the astonishing accuracy which has been introduced into astronomical calculations, and of the soundness of those principles on which the astronomy of comets is founded. It likewise shows that comets, in general, are *permanent* bodies connected with the solar system, and that no very considerable change in their constitution takes place while traversing the distant parts of their orbits.†

From the preceding historical sketches and descriptions, the reader will learn something of the *general phenomena* of com-

* Mrs. Somerville's "Connexion of the Physical Sciences;" a work which, though written in a popular style, would do honour to the first philosophers of Europe. Of this lady's profound mathematical work on the "Mechanism of the Heavens," the Edinburgh Reviewers remark, "It is unquestionably one of the most remarkable works that female intellect ever produced in any age or country; and, with respect to the present day, we hazard little in saying, that Mrs. Somerville is the only individual of her sex in the world who could have written it."

† The most particular observations on Halley's comet, during its appearance in 1835, which I have seen, are those which were made by the Rev. T. W. Webb, of Tretire, near Ross, an account of which, with deductions and remarks, was read to the Worcestershire Natural History Society. The observations were made with an excellent achromatic telescope by Tulley, of five feet six inches focal length, and 3 and 7-10ths inches aperture. Through the kindness of this gentleman I was favoured with a manuscript copy of these observations, and would have availed myself of many of his judicious remarks had my limits permitted.

ets; and I shall now briefly inquire into the opinions which have been formed respecting the

PHYSICAL CONSTITUTION OF COMETS.

On this subject our knowledge is very imperfect; in fact, we may be said to know little or nothing of the physical construction of those mysterious bodies, or of the nature of the substances of which they are composed. In regard to the *nebulosity* of comets, where there appears no nucleus, it has been conjectured to be composed of something analogous to globular masses of vapour, slightly condensed towards the centre, and shining either by inherent light or by the reflected rays of the sun. When there is a nucleus in the centre of a comet, it seldom happens that the nebulosity extends to it with a gradually increasing intensity. On the contrary, the parts of the nebulosity near the nucleus are but slightly luminous, and seem to be extremely rarefied and transparent. At some distance from their centre, their shining quality is suddenly increased, so that it looks like a ring of invariable size resting in equilibrium around the centre. Sometimes two, and even three of these concentric rings have been perceived separated by intervals; but what appears to be a ring must in reality be a *spherical covering*, an idea of which may be formed by imagining, in our atmosphere, at three different heights, three continued layers of clouds entirely covering the globe. The matter of the nebulosity is so rare and transparent that the smallest stars may frequently be seen through it.

As to the *nucleus*, it is generally considered as the solid or densest part of the comet. The *nuclei* of comets are sometimes very similar to the disks of planets, both in form and brightness. They are generally small compared with the whole size of the comet, but in some cases they are of considerable magnitude, as we have already stated in respect to the comets of 1807 and 1811. Some suppose that the nuclei of comets are transparent, as well as their nebulosities, and allege as a proof that stars have been seen through a nucleus. Thus, Montaigne is said to have seen a star of the sixth magnitude through the nucleus of a small comet, and Olbers saw a star of the seventh magnitude, although it was covered by a comet, and without its light being rendered less powerful; but the accuracy of such observations has been called in question. On the other hand, it has been concluded that the

nucleus of a comet has on several occasions eclipsed a star which was in the same line of vision. Messier, when observing the small comet of 1774, perceived a star which was eclipsed by the opaque body of a comet, or, at least, all the circumstances attending it led to that conclusion. On the 28th Nov., 1828, at $10^h\ 30'$ P.M., M. Wartmann, at Geneva, perceived a star of the eighth magnitude completely eclipsed by Encke's comet. Comets have likewise been observed to transit the disk of the sun like dark spots. M. Gambart, of Marseilles, calculated that a comet which he had observed would pass across the sun on the morning of the 18th November, 1826, and both he and M. Flaucerques were successful in obtaining a sight of it during its transit. Mr. Capel Lloffi, on the 6th June, 1818, at 11 A.M., saw a body passing over the sun's disk, which appears to have been a comet. It was likewise seen on the same day by Mr. Acton, at $2^h\ 30'$, considerably advanced beyond the point in which it was seen at 11 A.M., and its progress over the disk seems to have exceeded that of Venus in transit. These observations seem evidently to indicate that some comets at least have nuclei composed of solid and opaque materials. From all the observations in relation to this point, collected by M. Arago, he deduces the following conclusions: 1. That there exist some comets destitute of the nucleus. 2. That there are other comets, the nuclei of which are transparent. 3. That there are also comets which are more brilliant than the planets, the nuclei of which are probably solid and opaque.

In respect to the *tail*, or luminous train which generally accompanies comets, it is found that it is *generally* in opposition to the sun, or on the prolongation of the line which would join the sun and the nucleus. But this is not always the case. Sometimes the direction of the tail has been found at right angles with this line; and in some extraordinary instances, the tails of comets have been observed to point directly towards the sun, This was the case with a comet that appeared in 1824, which for about eight days exhibited a luminous train in opposition to that which assumed the ordinary direction. This anomalous tail, according to Olbers, was 7° long, while the other was only $3\frac{1}{2}°$, and it was bright enough to be seen with an opera-glass. In general, however, it is found that the tail inclines constantly towards the region last quitted by the comet, as if, in its progress through an ethereal medi-

um, the matter forming it experienced more resistance than that of the nucleus. The tail is generally enlarged in proportion to its distance from the head of the comet, and in certain cases it is divided into several branches, as already noticed of the comet of 1807. Some have supposed that the divided tail is nothing more than a perspective representation of the sides of a great hollow cone; but there are certain observations which seem to prove that, in some cases, they have a separate existence as independent branches. The most remarkable instance of a divided tail was in the comet of 1744. On the 6th and 7th of March there were six branches in the tail, each of them about 4° in breadth, and from 30° to 40° long. Their edges were pretty well defined and tolerably bright; their middle emitted but a feeble light, and the intervening spaces were as dark as the rest of the firmament. The tails of comets, as already noticed, sometimes cover an immense space in the heavens. The comet of 1680 had a tail which extended to 68°, that of 1811 to 23°, and that of 1769 to 97° in length; so that some of these tails must have reached from the zenith to the horizon. The length of the tail of the comet of 1680, estimated in miles, was 112,750,000; that of 1769, 44,000,000; and that of 1744, 8,250,000 miles. A body moving at the rate of 20 miles every hour would not pass over the space occupied by the tail of the comet of 1680 in less than 643 years. It has been supposed by some astronomers that certain changes in the appearance of the tails of comets arise from the rotation of the cometary body; as some comets have been supposed to rotate about an axis passing through the centre of the tail, such as that of 1825, which was concluded, from certain appearances, to perform its rotation in 20 hours, 30 minutes.

As to the nature of the immense tails of comets, their origin, or the substances of which they are composed, we are entirely ignorant, and it would be wasting time to enter into any speculation on this subject, as nothing could be presented to the view of the reader but vague conjectures, gratuitous hypotheses, and unfounded theories.

MISCELLANEOUS REMARKS ON COMETS.

1. *Whether comets shine with their own native light, or derive their light from the sun?*—This is a question about which

there have been different opinions, and at the present moment it may be considered as still undetermined, though the probability is, that, in general, they derive their light from the same source as the planets. It appears to have been the opinion of both Schroeter and Herschel, that the comet of 1811 shone by inherent light; and the rapid variations which have been observed in the brightness of the nucleus and the coruscations of the tail, are considered by some as inexplicable on any other hypothesis. It is likewise supposed, that certain phenomena which have been observed in the case of faint and rarefied comets tend to corroborate the same position. For example, Sir J. Herschel, on September 23, 1832, saw a small group of stars of the 16th and 17th magnitude through the comet of Biela. Though this group could have been effaced by the most trifling fog, yet they were visible through a thickness of more than 50,000 miles of cometary matter; and therefore it is supposed scarcely credible that so transparent a material, affording a free passage to the light of such minute stars, could be capable of arresting and reflecting to us the solar rays. On the other hand, it has been objected to this opinion, that comets have appeared as dark spots on the disk of the sun; that their light exhibits traces of *polarization;* and that they have been occasionally observed to exhibit *phases*. M. Arago remarks, that "on the very day that any comet shall appear with a distinct phase, all doubts on this subject will have ceased." But it is considered doubtful whether any *decided phase* has yet been perceived, although some observers were led, from certain phenomena, to infer that something like a phase was presented to their view. It is found that all direct light constantly divides itself into two points of the same intensity when it traverses a crystal possessing the power of double refraction; reflected light gives, on the contrary, in certain portions of the crystal through which it is made to pass, two images of unequal intensity, provided the angle of reflection is not 90°; in other words, it is *polarized* in the act of reflection. On this principle M. Arago pointed out a photometrical method of determining whether comets borrow their light from the sun, or are luminous in themselves. On the 23d of October, 1835, having applied his new apparatus to the observation of Halley's comet, he immediately saw two images presenting the complementary colours, one of them red, the other green. By turning the instrument half round, the red image

became green, and *vice versa.* He concluded, therefore, that the light of the comet, at least the whole of it, is not composed of rays possessing the property of direct light, but consists of that which is *polarized* or reflected specularly; that is, of light derived from the sun. These experiments were repeated with the same result by three other observers in the Observatory of Paris.

2. It appears to be a remarkable fact in respect to comets, that *the real diameter of the nebulosity increases proportionably as the comet* BECOMES DISTANT *from the sun.* Hevelius appears to have been the first who made this observation; but it seems to have been overlooked, and even an opposite position maintained. As the tails of comets increase in length as they approach their perihelia, so it was generally considered that the nebulosities followed the same law; but the observations which have lately been made on Biela's comet have confirmed the observations of Hevelius. On the 28th of October, 1828, this comet was found to be nearly three times farther from the sun than on the 24th of December, or in the proportion of 1.4617 to 0.5419, yet in October its diameter was about twenty-six times greater than in December, or in the proportion of 79.4 to 3.1; that is, its solid contents on the 28th of October were 16,800 times greater than on the 24th of December, and the *smallest* size of the comet corresponded to its *least* distance from the sun. M. Valz, of Nismes, and Sir John Herschel have attempted to account for this circumstance on very different principles, but neither hypothesis appears to be satisfactory.

3. *Whether a comet may ever come in contact with the earth, and produce a concussion?*—As comets move in orbits which form extremely elongated ellipses; as they move in all imaginable directions; as they traverse almost every part of the solar system in returning from the farthest verge of their excursions; as they penetrate within the interior of the planetary orbits, even within the orbit of Mercury, and cross the orbits of the earth and the other planets, *it is not impossible* that a comet may come in contact with our globe. An apprehension of such an event produced a considerable degree of alarm on the Continent at different periods, particularly in 1773 and 1832, as formerly stated. But when we consider the immense cubical space occupied by the planetary system in which the comets move, and compare it with the small ca-

pacities of these bodies; and when we take into view certain mathematical calculations in reference to the subject, the probability of a shock from a comet is extremely small. "Let us suppose," says Arago, "a comet of which we only know that at its perihelion it is nearer the sun than we are, and that its diameter is *one fourth* of that of the earth, the calculation of probabilities shows that of 281,000,000 of chances there is only one unfavourable, there exists but one which can produce a collision between the two bodies. As for the *nebulosity*, in its most general dimensions, the unfavourable chances will be from ten to twenty in the same number of two hundred and eighty-one millions. Admitting, then, for a moment, that the comets which may strike the earth with their nuclei would annihilate the whole human race, then the danger of death to each individual, resulting from the appearance of an *unknown* comet, would be exactly equal to the risk he would run, if in an urn there was only one single white ball of a total number of 281,000,000 balls, and that his condemnation to death would be the inevitable consequence of the white ball being produced at the first drawing."

When we consider that a Wise and Almighty Ruler superintends and directs the movements of all the great bodies in the universe, and the erratic motions of comets among the rest; and that no event can befall our world without his sovereign permission and appointment, we may repose ourselves in perfect security that no catastrophe from the impulse of celestial agents shall ever take place but in unison with his will, and for the accomplishment of the plans of his universal providence. At the same time, the *possibility* of a shock from a large comet shows us that this earth and all its inhabitants are dependant for their present existence and comforts on the will of an Almighty Agent, "in whom we live, and move, and have our being;" and that, were it conformable to his all-wise and eternal designs, he could easily disarrange the structure of our globe, and reduce its inhabitants either to misery or to complete destruction; and that, too, without altering a single physical law which now operates throughout the universe.

If we recognise the Scriptures as a revelation from God, we may rest assured that no danger from such a cause can happen to our world for ages yet to come; for there are many important predictions contained in revelation which

have not yet received their accomplishment, and must be fulfilled before any fatal catastrophe can happen to our globe. It is predicted that the Jews shall be brought into the Christian church "with the fulness of the Gentiles;" that "the idols of the nations shall be abolished;" that "wars shall cease to the ends of the earth;" that the kingdom of Messiah shall extend over all nations; that "the knowledge of Jehovah shall cover the earth, and that all shall know him from the least to the greatest;" that "the earth shall yield its increase," and its desolate wastes be cultivated and inhabited; that moral order shall prevail, and "righteousness and praise spring forth before all the nations;" and that this happy era of the world shall continue during a lapse of ages. These events have not yet been accomplished, though at the present moment they appear either in a state of commencement or of progression; but they cannot be supposed to be fully realized till after a lapse of centuries. The believer in Divine revelation, therefore, has the fullest assurance that, whatever directions comets may take in their motions towards the centre of our system, none of them shall be permitted to impinge upon our globe, or to effect its destruction, for at least a thousand years to come, or till the above and other predictions be completely accomplished.

4. Another question occurs on this subject, namely, *whether any comets have ever fallen into the sun?*—It was the opinion of Sir Isaac Newton, that one purpose for which comets are destined is to recruit the sun with fresh fuel, and repair the great consumption of his light by the streams continually emitted every way from that luminary; and that such comets as come very near the sun in their perihelions meet every time with so much resistance from his atmosphere as to abate their projectile force; by the constant diminution of which, the centripetal power, or gravitation towards the sun, would be so increased as to make them fall into his body. On a similar principle, Arago supposes that the comet of 1680, which approached so near the body of the sun, must have passed nearer to his surface at that time than at its preceding apparitions; that the decrease in the dimensions of the orbit will continue on each succeeding return to its point of perihelion; and that "*it will terminate its career by falling upon the sun.*" But he acknowledges that, "from our ignorance of the densities of the various strata of the sun's atmosphere, of

that of the comet of 1680, and of the time of its revolution, it will be impossible to calculate after how many ages this extraordinary event is to happen;" and he likewise admits that "the annals of astronomy do not afford any reason to suppose the previous occurrences of such an event since the origin of historical record;" so that we have no direct evidence that such an event has ever taken place, or that it ever will. We know too little of the physical constitution of the sun, and of the nature of comets, to be able to assert that the falling of a comet into the sun would actually recruit the luminous matter of which his outer surface is composed; for we have reason to believe that there is little or no analogy between the mode in which we supply our fires by means of fagots, and that by which the solar light is recruited and preserved in its pristine vigour; and besides, it is found that bodies, particularly in certain electric states, may be rendered luminous without the addition of any extraneous body to their substances.

ON THE INFLUENCE OF COMETS ON THE EARTH.

In former times, the appearance of comets was supposed to be the forerunner of wars, revolutions, famine, pestilence, the deaths of great men, earthquakes, inundations, and other calamities. When the splendid comet of 1456 appeared (supposed to be the same as Halley's comet), its tail extended at one time over more than 60 degrees. Three days before its perihelion, its nucleus was as bright as a fixed star, its tail of the colour of gold, and it appears to have exhibited coruscations. Pope Calixtus, believing it to be at once the sign and instrument of Divine wrath, was so frightened at its appearance that he ordered public prayers to be offered up in every town, and the bells to be tolled at the noon of each day, to warn the people to supplicate the mercy of Heaven. He at the same time excommunicated both the comet and the Turks, whose arms had lately proved victorious against the Christians, and established the custom, which still exists in Catholic countries, of ringing the church bells at noon. In modern times, certain natural effects have likewise been attributed to the influence of comets; such as tempests, hurricanes, volcanic eruptions, cold or hot seasons, overflowings of rivers, fogs, dense clouds of flies or locusts, the plague, the dysentery, the cholera, and other disorders.

Mr. T. Forster, a respectable writer on natural science,

author of "Researches about Atmospherical Phenomena," &c., published in 1829 a work on the "Atmospherical Causes of Epidemic Diseases," in which he maintains that the most unhealthy periods are those during which some great comet has been seen; that the appearance of these bodies has been accompanied by earthquakes, eruptions of volcanoes, and atmospheric commotions; and that no comet has been seen during seasons of healthiness. For example, in the year 1665, a comet made its appearance, and soon after its disappearance the city of London was ravaged by the plague. In 1680 one of the most splendid comets which have been observed in modern times made its appearance. The atmospheric effect produced by its influence, according to Mr. Forster, was "a cold winter, followed by a dry and hot summer," and "meteors in Germany." As the influence of comets on our globe and its atmosphere (if such an influence exist) must have a respect to the whole earth, and not merely to any particular portion of it, we might ask, in reference to the first example, why did not the comet of 1665 produce a smilar effect in Amsterdam, Vienna, Paris, and Madrid, and in the principal cities of Asia, Africa, and America? But of such effects we never had the least intimation. In respect to the second example, we are warranted to inquire whether the cold winter was followed by a hot summer in every other climate of the earth? whether meteors were as common in other countries as in Germany? and whether the comet produced opposite effects, at one time congealing the pools and rivers, and at another scorching the earth with heat? If such questions cannot be satisfactorily answered, we are not warranted in attributing such effects to the influence of comets.

We err egregiously in this as well as in many other respects, when we infer, from two contemporaneous events, that the one is either the sign or the *cause* of the other. It is on a principle of this kind that some persons are led to attribute the events to which we have alluded to the influence of comets. Because an inundation, a war, a political convulsion, or a volcanic eruption has taken place at the time of the approach of a comet to this part of our system, therefore they conclude that there must be a certain connexion between such events, and that the one is the cause and the other the effect; while the two events, in point of fact, may not have the slightest relation to each other, except their casual occurrence at the

same period. We might, on the same grounds, infer that the rising of the star *Sirius* along with the sun, which announced to the Egyptians the rise of the Nile, was the *cause* of the annual overflowing of that river. Before we can identify any event with the influence of a comet, we must not confine our views to an event or two in our immediate neighbourhood, but must endeavour to ascertain whether similar events or phenomena have happened *on every part of the earth* at the same period. As comets, either large or small, either visible to the naked eye or through a telescope, make their appearance at an average almost every year, and as epidemics, political commotions, earthquakes, hurricanes, and similar events are always to be found occurring in some particular portions of the globe, we should never be at a loss for a physical cause to account for everything that happens here below, if comets are to be supposed to have such an influence over terrestrial affairs. Whatever takes place in any country of an uncommon nature might then be attributed to a comet which is either approaching the centre of our system or receding from it.

It is remarkable, that the announcement of a comet has generally been received with melancholy anticipations, and the effects attributed to its influence have uniformly been of a calamitous nature. But why should it not be the precursor of prosperous events; of peace, plenty, social tranquillity, and genial seasons, as well as of wars, famines, revolutions, cold winters, and parched summers? It seems something like a reflection on the general benevolence of the Deity to imagine that he has created such a vast number of bodies, and directed their course through every part of the planetary regions, chiefly for the purpose of "shaking from their horrid hair" wars, famine, and pestilence; for, if they produce such effects upon the earth, we might with equal reason believe that they produce similar effects on the other planets of our system as they pass along in their course towards the sun; and this would lead us to infer that the inhabitants of all the planetary orbs are liable to the same disasters and calamities as the inhabitants of the earth, a position which seems scarcely consistent with the boundless benevolence of the Divine mind.

But, although I do not admit the conclusions and the cometary influences to which I have alluded, I am far from asserting that comets have no influence whatever over our globe or its surrounding atmosphere. The universe is one great

whole, and all its parts, however remote, must be supposed to have a certain relation to one another; and they may produce an influence, however small and imperceptible, on each other at the greatest distances. The remotest star perceptible to the eye may produce a certain physical influence on our globe, though so small and insensible as to be beyond the limits of the nicest calculation; and, therefore, comets which sometimes approach pretty near the earth may produce a certain sensible effect upon our globe, particularly should a portion of their immense tails at any time sweep along the higher regions of our atmosphere. But what special influence or effects they may produce on the physical economy of our terrestrial system it is impossible for us in the mean time distinctly to ascertain, from our ignorance of the constitution of those mysterious bodies, and of the substances of which they are composed. While too much has doubtless been attributed to the influence of comets, it would be verging to an opposite extreme to maintain that they can produce no effect at all on our earth and atmosphere. We know that certain celestial bodies produce a powerful influence on our globe. The moon, in conjunction with the solar influence, rules the ocean and perpetuates the regular returns of ebb and flow. Its light not only cheers our winter nights, but produces a variety of other influences both on the human constitution, the atmosphere, and on the productions of the earth; and there may be many effects produced by its agency with which we are as yet unacquainted.* The sun not only diffuses light over every

* It is stated by Mr. Martin, in his "Description of the Western Isles," that "peat dug in the increase of the moon continues moist, and never burns clear, while the contrary is observed of that cut in the decrease; and that earthen dikes thrown up in the latter season are alone found to possess stability." It is also stated as a fact, "that if an animal fresh killed be exposed to the moon's rays, it will in a few hours become putrid, while another animal, only a few feet distant, protected from their influence, will not be in the least affected; that fruits exposed to moonlight have been known to ripen much more readily; that plants bleached in the dark recover their colour from the beams of a full moon; and that in South America, trees cut at the full moon split almost immediately, as if torn asunder by great external force. Fish are said to be rapidly decomposed in the West Indies when taken by moonlight."—*Webb's MS. Treatise on Comets.* Unless such alleged facts can be *disproved*, we must admit that the moon may have a certain influence in such cases, though we may be unable to explain the mode by which it is effected. In Carne's "Letters from the East," we are told that "the effect of moonlight on the eyes in Eastern countries is singularly injurious. The

region of the earth for the purpose of vision, but rays or emanations invisible to our sight proceed from his body, which promote evaporation, the growth of vegetables, and the various degrees of temperature which prevail throughout the globe. These emanations are likewise found to produce certain chymical effects, to dissolve certain combinations of oxygen, and to give polarity to the magnetic needle; and many other effects of which we are ignorant may afterward be found to proceed from those invisible irradiations. The largest planets, Jupiter and Saturn, and those which are nearest to us, as Venus and Mars, may likewise produce certain effects on our globe, both in virtue of their attractive power and of the peculiar nature of the reflected rays they transmit to the region we occupy.

We cannot therefore but conclude, that comets may exert a peculiar influence on our terrestrial system in addition to that of the other celestial bodies, and different from it, particularly those whose bulk and masses are considerable, and which approach nearest to the earth. Their light, whether native or reflected, appears to be peculiar, and the margin of their immense tails may occasionally graze our atmosphere when we are not aware of it, and may produce a peculiar effect different from that produced by the other bodies of our system; but what that special effect is has not hitherto been determined; for the mere coincidence of certain events with the appearance of comets cannot be supposed to be owing to their peculiar influence, unless such events are found uniformly to happen on the apparition of a comet, and that, too, throughout a great portion of the earth. This subject is worthy of some attention; and perhaps future observers, by more accurate observations than have hitherto been made, may throw some light on an influence which, on the one hand, has been perhaps too rashly set aside, and on the other carried to a pitch of extravagance beyond the line of sober reason and observation.

natives tell you always to cover your eyes when you sleep in the open air. The moon here really strikes or affects the sight, when you sleep exposed to it, much more than the sun; a fact of which I had a very unpleasant proof one night, and took care to guard against it afterward. Indeed, the sight of a person who should sleep with his face exposed to the moon at night would soon be utterly impaired or destroyed." This circumstance strikingly illustrates the expression of the Psalmist: "The sun shall not strike or smite thee by day, *nor the moon by night*."

Let it not be supposed that, in admitting that comets may have an influence on our globe, I mean to give the least countenance to foolish superstitions, or to the absurdities of astrology, since all that I would be disposed to admit in the present case is purely a *physical* influence; an influence which may exist, although we have not yet been able to discriminate its specific effects. The most eminent philosophers have been disposed to admit such an influence. Sir Isaac Newton supposed that "the atmospheres and tails of comets may supply the planets with moisture, which is continually wasting by the growing of vegetables out of water and turning into earth;" and that from the same source may be derived "the purest part of our air which is requisite for the existence of living beings." These opinions, indeed, cannot be proved, and they are evidently untenable; but they show that that great philosopher admitted the influence of comets. M. Arago, although he scouts the vulgar idea of comets being the cause of most calamitous events, yet he admits that "not only cometary matter may fall into our atmosphere, but that this phenomenon is of a nature to occur frequently, and may possibly produce those epidemic diseases which have been attributed to it."

A variety of questions has been started respecting cometary action and influence, besides those to which we have now alluded. It has been a question whether we ought to have recourse to the action of a comet *to account for the rigour of the climate of North America?* It is found that in the northern regions of America, the climate in the same latitude is much colder than in Europe. To account for this, Dr. Halley supposed that a comet had formerly struck the earth obliquely, and changed the position of its axis of rotation. In consequence of that event, the North Pole, which had been originally very near to Hudson's Bay, was changed to a more easterly position; but the countries which it abandoned had been so long a time and so deeply frozen, that vestiges still remain of its ancient polar rigour, and that a long series of years would be required for the solar action to impart to the northern parts of the new continent the climate of their present geographical position. But we have no proof that a comet has ever struck the earth, or that its concussion would have the effect to change the direction of the terrestrial axis. Besides, it is well known that the Asiatic coast is equally cold

in the same latitudes as the Atlantic shores of North America.

It has likewise been a subject of inquiry, *whether the depression of the soil of a great part of Asia* has been produced by the shock of a comet? and *whether Siberia ever experienced a sudden change* by a similar event? This latter inquiry has been suggested by the circumstance of the bones of elephants, rhinoceroses, and other animals peculiar to the torrid zone, having been found imbedded in the strata of that country, which has led to the supposition that Siberia was, at some remote period, comprised within the tropics. But there is no proof, nor even probability, that the action of a comet was concerned in either case. It has also been supposed that the small planets, Vesta, Juno, Ceres, and Pallas, the supposed fragments of a large planet, may have been broken to pieces by the shock of a comet. The circumstance that two of these planets, Ceres and Pallas, are encompassed with an atmosphere of great density and elevation, has been brought forward as a presumptive proof of the reality of such a concussion, and that the cometary atmosphere, not being liable to destruction by the percussion, was imparted to these planets. But when we consider the very small density of comets, it appears not at all probable that even a direct concussion from such a body would have produced such an effect, although it might have caused a considerable derangement of the physical constitution of the planet. Besides, this hypothesis does not account for the remarkable fact that Vesta and Juno exhibit no traces of an atmosphere which, in consistency with the supposition, ought to have been imparted to them by the comet, as well as to Ceres and Pallas. On the whole, we have no direct or satisfactory proofs that comets have ever come in direct contact with our globe, or that they have produced any considerable derangements throughout the planetary system; and whatever specific influence they may produce on our earth and atmosphere must be deduced from future observations.

ON THE INHABITABILITY OF COMETS.

Some philosophers have been disposed to doubt whether the constitution of comets be at all fitted for the abode of rational beings, especially when we take into consideration the extremes of heat and cold to which they would be sub-

jected in their long and extensive career. Mr. Whiston supposed that on this account they could not be the abodes of happiness, and therefore was led to believe that they were the places of punishment for the wicked, who were alternately wheeled into regions of intolerable heat, and afterward exposed to all the rigours of the most intense cold. But when we consider the boundless beneficence of the Divine Being, and that "his tender mercies are displayed over all his works," we cannot for a moment suppose that so vast a number of these bodies would be created for such an end. The celebrated Lambert, on the other hand, considers comets as constituting some of the most splendid regions of the universe, and that their inhabitants are permitted to contemplate the scene of nature on a scale of grandeur far surpassing that which is presented to the population of the planets.

Many of the comets which exhibit no signs of a nucleus appear to be composed of very light, transparent, and gaseous substances; and therefore it is not very probable that such bodies are inhabited. Comets in this state are supposed by some philosophers to be only approaching to a state of consolidation. But as to those which have a large and solid nucleus, there appears to be no physical impossibility, nor even improbability, of their being the abodes of sentient and intellectual beings, as well as the other moving bodies of our system. The extremes of heat and cold to which comets are supposed to be subjected forms the principal argument against the opinion that these bodies are inhabited. But, in reply to such an objection, it may be stated, that we have no proof that heat or cold depend altogether on the distance of a body from the sun, but most probably on certain circumstances connected with the constitution of the body itself. Besides, it is a fact, that in the heating of bodies there is a certain point beyond which their temperature can never be raised; as, for instance, in the case of water, which cannot be heated beyond the point of 212° of Fahrenheit's thermometer; and, therefore, the surface of a comet may have a certain point beyond which its temperature can never be elevated, even at its nearest approach to the sun. "When, by any means," says Mr. Milne, "the density of bodies is made to change by a process, whether of rarefaction on the one hand, or of condensation on the other, they are always found to undergo a corresponding diminution or increase of temperature. When, therefore

in the approach of a comet to the sun, all the parts of its nebulous envelope and tail, which, in the remoter regions of its course, had been gathered close about the head, become expanded and attenuated, a very large proportion of the solar heat, which would otherwise have passed into the nucleus, and contributed to raise its temperature to a certain point, is carried off by the envelope and tail, in order to preserve an equilibrium among the several parts." Mr. Milne proves that, if we assume that the nebulous matter is elevated about 30 times its former height, the diminution of density corresponding with the increase of volume will amount to 27,000, and that a quantity of caloric will be abstracted corresponding to 1,215,000° of Fahrenheit. He further shows that, "when the comet retires towards its aphelion, where the heat of the sun becomes so much weakened on account of the distance, the condensation of the nebulous matter forming the tail and envelope serves not only to furnish the nucleus with continual supplies from the heat acquired at the perihelion, but even to render the warming influence of the solar rays much more efficacious than at a less remote part of the comet's orbit."*

The extremes of heat and cold, therefore, in comets may not be so great as at first view we should be apt to imagine, and their constitution may be such as is not incompatible with the idea that they are inhabited by animated beings. We are not, however, to suppose that the constitution of beings like man would be adapted to the circumstances and changes to which comets are subjected, nor is such a supposition necessary in order to prove their inhabitability. For in the case of all worlds and beings, we must necessarily admit that the Creator has adapted the constitution of the inhabitants to the nature of the habitation. We find a striking variety in this respect in the constitution of the numerous orders of sentient beings that people the globe on which we live; and a similar variety doubtless exists in the peculiar constitutions of the inhabitants of the different planets, and of all the worlds in the universe. For anything we can prove to the contrary, some of the comets may be the abodes of greater happiness than is to be found in our sublunary world, and may be peopled with intelligences of a higher order than the race of man. In consequence of the extensive regions through which they

* Milne, Prize Essay on Comets, Part IV.

move, and the variety of objects which will successively burst upon their view, their prospects of the scenes of the universe will be far more diversified and expansive than those of the inhabitants of the planets.

At one period they will behold the stupendous globe of the sun filling a great portion of their celestial hemisphere, and be enabled to contemplate the august and splendid operations going on upon its surface and in its luminous atmosphere, a spectacle of grandeur which must be beyond conception sublime and overpowering. At another period they will be enabled to survey, at no great distance, the phenomena and economy of some of the planetary worlds. The comet of 1744 passed within 180 terrestrial diameters, or 1,440,000 miles of the earth's surface, at which time its inhabitants (if any) would enjoy an interesting view of our earth and moon, with their diversified motions, and the general aspect of their surfaces. The same comet twice traversed the system of Jupiter's satellites, when the magnificent globe of Jupiter would appear at least 300 times larger than the moon appears to us, and when its satellites would likewise present a very large and splendid appearance. From such a position, even with eyes such as ours, assisted by telescopes, all the diversity of surface of this huge globe, as presented in its diurnal rotation, with the changes of its belts, and the peculiar scenery of its satellites, would be distinctly perceived. Above all, the system of Saturn will present a most magnificent spectacle to the inhabitants of a comet when it passes through the regions in its immediate vicinity. Its expansive rings, filling a considerable portion of the visible firmament, their rapid rotation round the planet, the vast globe of Saturn itself, and the numerous satellites which accompany it, in all their different phases and rapid motions, will present a scene at once diversified and sublime. To the inhabitants of comets, many vast bodies within the range of our system may be visible, which we have never yet discovered, and which may never be perceptible from the region we occupy. Traversing vast regions of space far beyond the orbit of Uranus, and perhaps approaching to the nearest stars, worlds may be presented to their view of which we have no conception, and the planets which revolve around other suns may be distinguishable in the remoter parts of their course. Enjoying such diversified and extensive prospects of the operations of Omnipotence, the intellectual beings who

reside on those bodies will acquire more expansive views than the inhabitants of the earth of the vast scene of nature and of the perfections of that All-wise and Almighty Being, whose power brought into existence, and whose incessant energy sustains in being, all the worlds in the universe.

The number of comets is supposed by some astronomers to amount to several millions; and, if so, they must frequently pass near each other in their long eccentric courses, and consequently the beings connected with them will have their prospects of other worlds wonderfully diversified and continually expanding. It is likewise supposed that comets sometimes extend their excursions to other suns. On this point M. Lambert has the following remarks: "I shall suppose that a globe in our system begins to describe a parabola. If this curve closes and returns into itself, the globe will remain with us, and acquire a periodical motion round the sun. If, on the contrary, it extends its limits so as to become a hyperbola, the globe will recede more and more from the sun, and leave us, never to return. Were we to pursue the fugitive in idea, we should see it, perhaps, at the end of some thousands of years, flit along the frontiers of our system and dive into a neighbouring world. The central body of this world would then exercise its attraction over the new visiter, and give a curvature to his orbit. From that moment one of two things would happen. Either its path would change into an ellipse, in which case its travels would be at an end, and it would proceed to make regular revolutions round the dominant star of that system; or, perhaps, after passing its perihelion, it would again resume its hyperbolic progress, and, approaching the asymptote, withdraw in a straight line, and proceed to visit other worlds. Thus we can conceive comets which, being attached to no particular system, are in common to all, and which, roaming from one world to another, make the tour of the universe. I ask why, in the infinite variety which the Creator has introduced into his works, such globes should not have a place? Their destination may embrace the wisest purposes, concerning which we may be allowed to speculate."

This celebrated philosopher concludes his remarks on comets with the following reflections, which, although somewhat fanciful, may not be unworthy of the attention of the reader:

"I love to figure to myself those travelling globes, peopled

with astronomers, who are stationed there for the express purpose of contemplating nature on a large, as we contemplate it on a small scale. Their moveable observatory, cruising from sun to sun, carries them in succession through every different point of view, places them in a situation to survey all, to determine the position and motion of each star, to measure the orbits of the planets and comets which revolve round them, to observe how particular are resolved into general laws, in one word, to get acquainted with the whole as well as the detail. We may suppose that their year is measured by the length of their route from one sun to another. Winter falls in the middle of their journey; each passage of a perihelion is the return of summer; each introduction to a new world is the revival of spring; and the period of quitting it is the beginning of their autumn. The place of their abode is accommodated to all their distances from the fixed stars, and the different degrees of their heat make the fruits and vegetables designed for their use blossom and ripen. Happy intelligences, how excellent must be the frame of your nature! Myriads of ages pass away with you like so many days with the inhabitants of the earth. Our largest measurements are your infinitely small quantities; our millions the elements of your arithmetic; we breathe but a moment; our lot is error and death, yours science and immortality. All this is agreeable to the analogy of the works of creation. The frame of the universe furnishes matter of contemplation as a whole as well as in each of its parts. There is not a point that does not merit our observation; this magnificent fabric is portioned out in detached parts to created beings; but it is in the unity of the whole that sovereign perfection shines; and can we suppose that this whole has no observers? The imagination, indeed, after so sublime a flight, may be astonished at its own temerity; but, in short, here the cause is proportioned to the effect, and there is nothing great or small in immensity and eternity."

ON THE MOTIONS AND ORBITS OF COMETS.

When a comet comes within the limits of our view, its apparent motion is from east to west, and it generally appears to rise and set like most of the other heavenly bodies. This motion, however, like that of the diurnal motion of the sun and planets, is only *apparent*, and arises from the rotation of

the earth upon its axis. Besides this apparent motion, it has a *real* and proper motion of its own, by which it is continually shifting its place in the heavens, in conformity to the nature of the orbit in which it moves. "The proper course of a comet may be found by observing every night its distances from two fixed stars whose longitudes and latitudes are known; or by finding its altitude when in the same azimuth with two known fixed stars; or by noting four fixed stars in the point of intersection of the two lines connecting which the comet is found. If the places of the comet, as thus observed every night, be marked on the celestial globe, a line drawn through them will represent the comet's path among the stars; a great circle drawn through three distant places will nearly show the way it has to go. If it be continued till it intersect the ecliptic, it will show nearly the place of the node and the inclination of the orbit to the ecliptic."* There is, however, a practical difficulty which perplexes the observer in attempting to ascertain the true form of a cometary orbit. A comet remains so short a time in sight, and describes so small a part of its course within our view, that, from observation alone, without the assistance of hypothesis, we should not be able to determine the nature of its path. The only part of the course of a comet that can ever be visible is a portion throughout which the ellipse, the parabola, and hyperbola, so closely resemble each other that no observations can be obtained with sufficient accuracy to enable us to distinguish them. The hypothesis most conformable to analogy is, that the comet moves in an ellipse, having the sun in one of the foci, and that the *radius vector* from the sun to the comet describes areas proportional to the times, according to the law observed by the planets. If it be supposed that the comet describes an ellipse or a parabola, in conformity to the laws of Kepler, then from three geocentric places, known by observation, the orbit may be determined.

The orbits of the planets, although elliptical, approach very nearly to circles; but those of comets are extremely eccentric, and form very elongated ellipses. The orbit of Halley's comet is four times longer than it is broad, and the orbits of those comets whose periodical revolution exceeds a hundred or a thousand years must be still more elongated and eccentric. The following figure represents the orbit of Hal-

* Dr. O. Gregory's "Treatise on Astronomy."

Fig. 83.

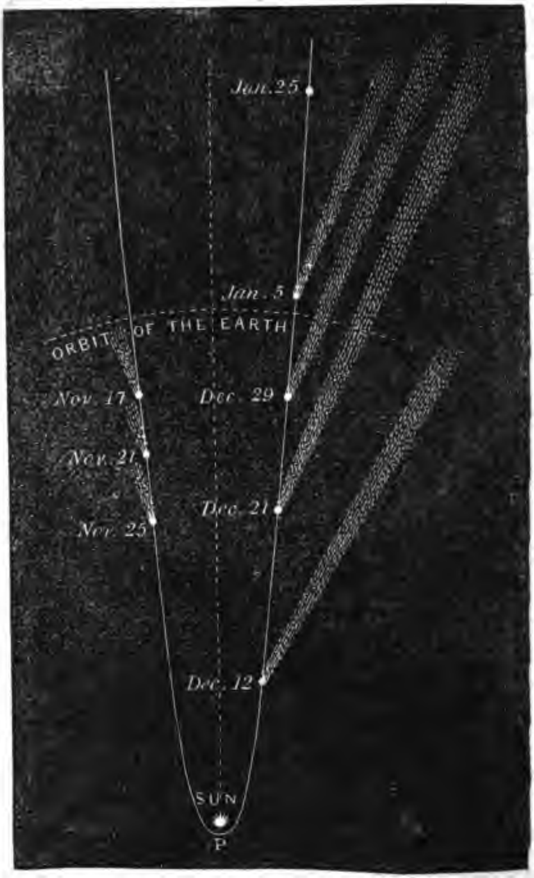

Jan. 25
Jan. 5
ORBIT OF THE EARTH
Nov. 17
Dec. 29
Nov. 21
Dec. 21
Nov. 25
Dec. 12
SUN
P

Fig. 84.

Representation of the Orbit of THE COMET OF 1832, with the relative POSITION OF THE ORBIT OF THE EARTH.

ley's comet nearly in its exact proportions. *E C* represents the length of the ellipsis in which it performs its revolution; *E D*, the orbit of the earth, somewhat larger than it ought to be in proportion to the comet's orbit; *S*, the sun in one of the foci of the ellipse; *Sat.*, the proportional distance of the planet Saturn from the sun; and *U*, the proportional distance of Uranus. The orbit of this comet extends to nearly double the distance of Uranus:

Fig. 82.

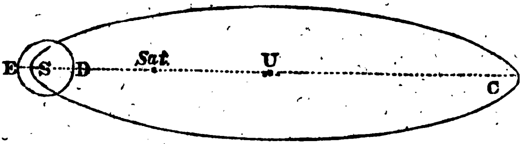


Fig. 83 represents so much of the trajectory of the comet of 1680 as it passed through, while visible to the inhabitants of our globe, as delineated in Newton's "*Principia.*" It shows also the tail as it appeared on the days mentioned in the figure. Like that of other comets, it increased in length and brightness as it came nearer the sun, and grew shorter and fainter as it went farther from that luminary and from the earth, till the comet was too distant to be visible. This comet was observed in the morning, from November 4 to November 25, 1680, in its descent towards its perihelion at *P*; and its positions on the 17th, 21st, and 25th of that month are here exhibited. It appears to have passed its perihelion some time between the 25th of November and the 12th of December. Its positions on the 12th, 21st, and 29th of December, and on the 5th and 25th of January, 1681, after returning from its perihelion, as seen in the evening, are marked in the figure. The orbit of this comet must be extremely elongated, as its return is not expected for more than 400 years to come.

Fig. 84, taken from Arago's "Scientific Notices of Comets," exhibits a representation of the orbit of Biela's comet, with the relative position of the orbit of the earth. It shows both the space and the position it occupies in the solar system, and the points where its orbit intersects all the planetary orbits through which it passes. It exhibits its course at its

return in November, 1832, and the path it describes till its subsequent return in 1839. From this figure it is seen that its perihelion lies between the orbits of the earth and Venus, and that its aphelion extends beyond the orbit of Jupiter. It would arrive at that point which is most distant from the earth in the spring of 1836, and will probably return to it in January, 1843. The nearest approach to the earth of this comet was 51 millions of miles; its nearest approach to the sun, 83 millions; its mean distance from the sun, or hal. the longest axis of its orbit, 337 millions; and it is 507 millions of miles nearer the sun in its perihelion than in its aphelion. To be able to calculate and predict the future positions and appearances of such a body, evinces an accuracy of observation and a degree of perfection of astronomical *calculus* which may justly challenge admiration, and which should lead those who are unacquainted with the minutiæ of astronomy to receive with confidence the results which have been deduced by those who have devoted themselves to celestial investigations.

SUPPOSED NUMBER OF COMETS.

It is laid down as a principle by M. Lambert, that as the world is the expression of the perfections of God, we must believe that all the heavenly bodies are inhabited, and "*that universal space is replenished with as many globes as it can contain*," so as to move with freedom and security within the circumference of the universe. Hence he infers that the most perfect plan of our system will be that into which enters the greatest number of orbits, all separated from one another, and which in no one point intersects the other; and that the orbits of comets correspond to this end better than those of the planets, as an immensely greater number of elliptic or cometary orbits can be introduced into the system than of those which are circular. On the ground of the number of comets which have hitherto been observed, and on certain mathematical considerations, he instituted calculations which led to the conclusion that "at least five hundred millions of comets" might be contained within the limits of the solar system. On this point M. Arago reasons in the following manner: The number of comets really known, whose perihelion is less than the radius of the orbit of Mercury, amounts to thirty. This radius, and that of the orbit of Uranus, are in

the ratio of 1 to 49; and the volumes of two spheres are to each other as the cubes of their radii. If, therefore, we adopt the hypothesis of the equal distribution of comets in all the regions of our system, and calculate the number of those luminaries whose perihelions are included in a sphere whose radius is the distance of Uranus from the sun, the following proposition would be supplied to us: As the cube of 1 : to the cube of 49 : : so is 30 : to the number of comets sought; or thus, $1^3 : 49^3 :: 30$; or, 1 : 117,649 : : 30 : 3,529,470. Thus, within the orbit of Uranus, the solar system should contain more than three millions and a half of comets; or we should rather find the double of that the true number, when we consider that in this calculation the term which represents the number of comets contained within the sphere of Mercury is certainly much too small, and that it ought to be conceded that the light of day, our clouded skies, and a too southerly declination, removes from our sight not fewer than every alternate one of these bodies. Taking these circumstances into consideration, there should, on the same hypothesis, be seven millions of comets.

The actual number of comets, however, which have been observed since the commencement of the Christian era, does not amount to above seven or eight hundred; but when we consider that in the earlier ages of astronomy, and likewise in more recent periods before the invention of the telescope, only large and conspicuous comets were noticed, and that the greater number, in all probability, had their visible course in the southern regions of the heavens, and of whose appearance we have no records, it will easily be conceived that their actual number must amount to at least many thousands. Since particular attention has been directed to the astronomy of comets, and since the number of observers has increased, scarcely a year has passed without the observance of one or two of these bodies, and sometimes even two or three have appeared at once. In the year 1825, no less than *four* comets made their appearance within the space of three months. The first of these was discovered by M. Gambart, at Marseilles, on May 9, in the head of *Cassiopeia*; the second, by M. Valz, at Nismes, on July 13, in *Taurus*; the third, by M. Pono, at Florence, on August 9, in *Auriga*; the fourth, or Encke's comet, about the months of July or August. But it is evident that multitudes must escape all observation, by rea-

son of their paths traversing only that portion of the heavens which is visible in the daytime.

The number of comets whose paths have been particularly observed during their visible course is about 137. Of these, sixty-nine moved in a *direct* course, or according to the order of the signs, as the planets do, and sixty-eight in a retrograde direction. As to the *distances of their perihelions* from the sun and the earth, thirty were found to have their perihelions between the orbit of Mercury and the sun; forty-four between the orbits of Mercury and Venus; thirty-four between the orbits of Venus and the Earth; twenty-three between the orbits of the Earth and Mars; six between the orbits of Mars and Jupiter. Beyond the orbit of Jupiter no comets have been perceived; and it is seldom they can be seen beyond the orbit of Mars. As to *the inclination of their orbits*, nine comets have been observed whose orbits incline to the ecliptic from 0° to 10°; thirteen from 10° to 20°; ten from 20° to 30°; seventeen from 30° to 40°; fourteen from 40° to 50°; twenty-three from 50° to 60°; seventeen from 60° to 70°; nineteen from 70° to 80°; fifteen from 80° to 90°. It appears, then, that these 137 comets had their orbits inclined in almost every degree to the ecliptic; and it is probable that this is the case with all the other comets which belong to the system.

Although comets generally emit an obscure light, yet some have been seen whose splendour was so great as to be visible in daylight, even at noon, and while the sun was shining in all his brightness. Such, it is said, were the comets which appeared in 1402 and 1532, and that which appeared a little before the assassination of Cæsar, and which was supposed, after that event happened, to have been an omen or prelude of his death. It has likewise been stated, that comets have appeared of such a magnitude as to have eclipsed the sun. Seneca relates that such a coincidence happened sixty years before Christ, when a large comet was actually observed very near the sun.* The same author relates that a comet which appeared in the time of the Emperor Nero was not inferior in apparent magnitude to the sun himself;† and the comet which Hevelius observed in the year 1652 did not seem to be less than the moon, though it was deficient in splendour.

* Sir. J. Herschel's Astronomy.
† Dr. O. Gregory's Astronomy

Comets traverse all parts of the heavens; and, as already noticed, their orbits have every possible inclination to the plane of the ecliptic. They are, however, governed in their motions by the same physical laws which regulate the motions of the planets. Their periodical times are to the periodical times of the planets in the sesquiplicate ratio of their principal axes. Comets, therefore, being for the most part beyond the planetary regions, and on that account describing orbits with much larger major axes than the planets, revolve more slowly. Thus, if the major axis of a comet's orbit be four times as long as that of the orbit of Uranus, the time of the comet's period would be to that of the planet as 8 : 1; its periodic time would therefore be nearly 672 years; that is, 8×84 = the period of Uranus = 672. Although comets move with great rapidity when near their perihelion, yet in the remote parts of their course their motion must be proportionally slow.

The motions of comets when approaching the sun are in certain cases extremely rapid. The comet which was observed by Regiomontanus, in 1472, was said to have passed through 40 degrees of a great circle in twenty-four hours. Brydone, in his "Tour through Sicily," relates that he observed a comet at Palermo, in June and July, 1770, which moved through 50 degrees of a great circle in twenty-four hours. At midnight, on the 30th of June, it passed the zenith of Palermo (latitude 38° 10′), and the next day, July 1, at 40 minutes past eight P.M., it passed 4 degrees to the east of the polar star. He remarks that, "supposing it at the distance of the sun, at this rate of travelling it would go round the earth's orbit in a week, which makes about 80 millions of miles a day; a motion that vastly surpasses all human comprehension. And as this motion continues to be greatly accelerated, what must it be when the comet approaches still nearer to the body of the sun!" It is probable, however, that the comet was considerably nearer the earth than the distance of the sun; but still the velocity with which it was impelled must have been amazingly great.

Such is a brief summary of the most remarkable facts, interesting to general readers, which have been ascertained in relation to comets. It is to be hoped that, in the progress of astronomical discovery, some additional light will be thrown on the nature and the destination of those mysterious bodies,

whose number appears so far to surpass that of the primary and secondary planets of our system. It was long ago predicted by Seneca, a Roman philosopher who lived in the first century of the Christian era, "that the time will come when the nature of comets and their magnitude will be demonstrated, and the courses they take so different from those of the planets; and that posterity will wonder that the preceding ages should be ignorant in matters so plain and easy to be known." In order that this prediction may be fully realized, it is requisite that we should become acquainted with all the observations that have hitherto been made, and the facts in relation to these bodies which have been ascertained; that we should compare the various observations with each other, and attend to the minutest circumstances and phenomena connected with comets; that numerous observers should be appointed to survey different portions of the firmament, both in the northern and southern hemispheres, that no comet that comes within the limits of our vision may pass unobserved; and that when a comet of a large size approaches near the centre of our system, every minute particular in reference to its motions, and the changes which take place in its nucleus, envelope, and tail, be carefully observed and delineated by accurate representations.

Whatever opinions we may adopt as to the physical constitution of comets, we must admit that they serve some grand and important purpose in the economy of the universe; for we cannot suppose that the Almighty has created such an immense number of bodies, and set them in rapid motion according to established laws, without an end worthy of his perfections, and, on the whole, beneficial to the inhabitants of the system through which they move.

They display the *wisdom* of their Creator *in the arrangements of their orbits and motions*. As we have every reason to conclude that at least thousands of those bodies traverse the solar system in all directions, and are certain that their orbits are inclined in every possible degree to one another and to the orbit of the earth, so we find that they have been so admirably arranged by Divine Intelligence that no one of them interferes with another, or with the courses of the planets, so as to produce concussion or disorder. The orbits of some comets, indeed, are found to approach very near, and even to cross the orbit of the earth and the orbits of several

of the other planets, and, consequently, there is a *possibility* that a comet might come into concussion with our globe; and this consideration shows us that we are dependant for our present security and comforts on the wise arrangements of the Almighty, in securing perfect harmony and order amid apparent danger and confusion. But we have no evidence that such a catastrophe has ever happened, either in the case of the earth or of any of the other planets, or that one comet has ever impinged upon another. Believing that every object and event in the universe is arranged and directed by an Omnipotent Contriver, we must admit that when the Almighty formed the wondrous plan of creation, "foreseeing the end from the beginning," he arranged the periods and the velocities of comets in such a manner that, although occasionally crossing the planetary orbits, they should not pass these orbits at the time when the planets were in their immediate vicinity. And should such an event ever occur, we may rest assured that it is in perfect accordance with the plan and the will of Omnipotence, and that it is, on the whole, subservient to the happiness and order of the intelligent universe, and the ends intended by the Divine government. If there are thousands, and perhaps millions of comets of all descriptions traversing every part of the planetary regions, in orbits of every degree of inclination, of extent, and of eccentricity, we are sure that none but a Being of infinite power and intelligence could have arranged such a vast and complicated system, so as to have prevented numerous interferences and disasters, and to make the whole move onward for ages in perfect harmony.

The system of comets likewise presents to us a display of *the omnipotence and grandeur of the Deity*. The number of these celestial visiters, the vast magnitude of their tails, envelopes, and nuclei, and the amazing velocity with which they wheel their courses through the ethereal regions, exhibit before us objects of astonishing grandeur, and evince the almighty power of Him who at first impelled them in their rapid career. The diameter of the nucleus of the comet of 1807 was estimated by Schroeter at 4600 miles, and that of its coma 120,000 miles. Besides its principal tail, it shot forth coruscations to the extent of four millions, six hundred thousand miles. The nucleus of the comet of 1811 was, according to the same observer, 50,000 miles in diameter, its coma or envelope 947,000 miles and its tail or train of light sixty millions of miles in length

or more than half the distance between the earth and the sun. Let us conceive such a body, like the comet of 1680, traversing the immense spaces of creation with a velocity of ten hundred thousand miles an hour, and drawing after it a luminous train a hundred millions of miles in length, approaching at one time so near the sun that his circumference would appear to fill the greater part of the firmament, and then rushing back through the depths of immeasurable space thousands of millions of miles beyond the orbit of Uranus, and displaying its majestic train to the other planetary worlds of our system, and we have presented to our mental eye an object of peculiar grandeur and magnificence, different from everything else which the planetary system exhibits, and which displays in an eminent degree the power and magnificence of the Great Creator. Were such a body to sweep along the regions which lie in the immediate vicinity of our globe, at the distance of ten or twelve thousand miles, nothing that we have ever beheld or can well conceive could be compared to the majestic grandeur of the scene, which would overpower the mind with astonishment and with terror. On the view of such an object, sweeping along with such velocity, we could scarcely refrain from exclaiming, in the language of inspiration, "Great and marvellous are thy works, Lord God Almighty!" What, then, shall we think of thousands of such mysterious orbs winging their flight in every direction, in perfect regularity and order, through the immensity of space! Surely these are the wonderful works of Him who is mighty in operation and perfect in knowledge.

In all the works of the Deity, we must likewise admit that his *goodness* is displayed, although we may not be able to trace the mode of its communication; for we may lay it down as an axiom, that wherever wisdom and omnipotence are exhibited throughout the Divine economy, there is also a display of *beneficence*, which appears to be one prominent design of all the works of God. Comets have long been considered as objects of terror and as omens of impending calamities; but there can be no question that they are as intimately connected with a system of benevolence as are the solar radiations and their benign influence on our globe and on the other planets. It has been conjectured that comets may supply moisture to the other planets, and invigorate the vital principle of our atmosphere; that they may recruit the sun with fresh fuel, and

repair the consumption of his light; or that they may be the agents for dispersing the electric fluid through the planetary regions; and although there is little probability that such conjectures are accordant with fact, yet it may be admitted that comets may produce a *physical* influence of a beneficial nature throughout the solar system. But what I conceive to be one of the main designs of the Creator in the formation of such a vast number of splendid bodies is, that they may serve as habitations for myriads of intellectual beings, to whom the Almighty displays his perfections in a peculiar manner, and on whom he bestows the riches of his beneficence. Whatever may be the intention of those comets which are destitute of a nucleus, this, in all probability, is the chief design of those which are large and which are invested with a solid nucleus; and the same arguments which we formerly brought forward to prove that the planets are inhabited, might be adduced in proof of the inhabitability of comets. If this position be admitted, then we ought to contemplate the approach of a comet, not as an object of terror or a harbinger of evil, but as a splendid world, of a different construction from ours, conveying millions of happy beings to survey a new region of the Divine empire, to contemplate new scenes of creating power, and to celebrate in loftier strains the wonders of Omnipotence. Viewing the comets in this light, what an immense population must be contained within the limits of the solar system, which gives room for the excursions of such a vast number of these bodies! and what an incalculable number of beings of all ranks must people the wide-extended universe!*

* The most complete account of the phenomena, &c., of comets I have seen, is a treatise on this subject in manuscript, by the Rev. Thomas W. Webb, of *Tretire*, near *Ross*. This treatise contains, 1. A copious introduction, imbodying a variety of interesting general remarks in relation to this subject. 2. A particular account of the comet of 1807, according to the observations of Sir William Herschel. 3. A description of the same comet from the observations of Dr. Johan. Hieron. Schroeter. 4. An account of the great comet of 1811, according to the observations of Sir W. Herschel. 5. A particular description of the phenomena of the same comet, according to the observations of Schroeter. 6. A description of the second comet of 1811, according to the observations of Sir W. Herschel. These observations, particularly those of Schroeter, contain the most minute descriptions which have hitherto been given of the phenomena of this class of the celestial bodies, and will be found of essential service, not only to amateur observers, but to astronomers of every description. They have been extracted and arranged chiefly from the "Philosophical Transactions," and the works of Schroeter

which were published in the German language. The *Appendix*, or Second Part, which occupies nearly half the volume, comprises a lucid investigation of the following topics: 1. Comparison of observations. 2. Examination of hypotheses. 3. Nature, light, and solidity of comets. 4. Colours of comets. 5. Brightness of comets. 6. Divided tails of comets. 7. Coruscations of comets. 8. Miscellaneous notices concerning remarkable comets. 9. On the influence of comets. 10. Losses to science, containing an account of the disasters which befell Schroeter, Hevelius, &c. 11. Hints to amateur observers. This volume contains 230 4to pages, besides a great number of copious notes, and forty-six figures of the different appearances of comets. It indicates a very great degree of labour and research, which the astronomer alone will be fully able to appreciate. The author appears to have consulted most of the works which have been published on the subject in the English, Latin, French, and German languages, besides imbodying a number of original observations and remarks. And, what is not among the least important features of the work, the author takes every opportunity of introducing such moral reflections as the subject naturally suggests, and of directing the contemplations of his readers to Him who sits on the throne of the universe. The observations of Schroeter contained in the preceding pages have been extracted from this volume. It is to be hoped that the worthy author, who is already known to a considerable portion of the scientific world by his communications to periodicals and scientific associations, will soon receive encouragement to lay this work before the public.

APPENDIX.

GENERAL APPEARANCE OF THE STARRY HEAVENS AT DIFFERENT PERIODS OF THE YEAR.

The following descriptions are intended to point out to the young observer the principal stars and constellations in the beginning of every alternate month throughout the year, and the particular quarter of the heavens where they may be perceived. The time of observation is supposed to be *nine o'clock in the evening*, except on the 1st of July; but the general aspect of the heavens, and the relative positions of the different stars and constellations, will not be materially different when viewed an hour before or after the time now specified.

Aspect of the Heavens on the 1st of January, at nine o'clock in the evening.

At this time the *Pleiades*, or Seven Stars, are nearly on the meridian, at an elevation of more than 60 degrees above the southern horizon. The bright star *Aldebaran*, or the Bull's Eye, which is of a ruddy hue, appears to the left, in a direction nearly east by south, at the distance of 14°. About 15° east-northeast of Aldebaran is a bright star of the second magnitude, marked *Beta*, or El-Nath; from this star to *Zeta*, in the tip of the southern horn of the Bull, is about 8° in a southern direction. This star forms a right angle with Aldebaran and Beta. North of Beta, at the distance of 17°, is the bright star Capella, in the constellation of Auriga, a star of the first magnitude, which appears at a high elevation a few degrees southeast of the zenith. In a direction southeast of Aldebaran and the Pleiades is the splendid constellation of *Orion*. *Bellatrix*, on the west shoulder of Orion, is about 16° southeast of Aldebaran, which is placed in the middle

of the line which connects the Pleiades with Bellatrix; these three objects appearing nearly equidistant in a line N.W. and S.E. of each other. Nearly due east from Bellatrix, at the distance of 7½°, is Betelguese, a star of the first magnitude in the east shoulder of Orion. About 15° south by west of Bellatrix is *Rigel*, a star of the first magnitude in the left foot, and 8½° to the east is *Saiph*, a star of the third magnitude in the right knee of Orion. These four stars in the form of a parallelogram, with the three bright equidistant stars called the *Belt*, form the outlines of this constellation. There is a small triangle of three small stars in the head of Orion which forms a larger triangle with Bellatrix and Betelguese, the two in his shoulders. (*See* fig. of Orion, p. 50, and Plate I.)

Northeast of Betelguese, at the distance of 14°, is the star *Alhena*, or γ Geminorum, the principal star in the feet of the Twins; and about 20° N.E., nearly in the same right line from Betelguese, are *Castor* and Pollux, Castor being the uppermost and the brightest, at the distance of only 4½° from Pollux. These and the other stars which lie adjacent to them form the constellation Gemini, one of the signs of the Zodiac. The small stars immediately to the east of Gemini are in the constellation *Cancer*, another zodiacal constellation through which the sun passes in July and August. In this constellation is a nebulous cluster of very small stars, called *Præsepi*, which may be distinguished as a faint cloudy speck by the naked eye. (*See* page 162.)

Immediately below Orion are the constellations of *Lepus*, or the Hare, and Noah's Dove, which are very near the horizon. South by east of Orion is *Canis Major*, or the Greater Dog, which is distinguished by its principal star *Sirius*, the brightest fixed star in the heavens. It is nearly straight south of Alhena, in the feet of the Twins, at 35° distant, and south by east of Betelguese at the distance of 27°. A line drawn through the three stars in the belt of Orion, and prolonged, meets Sirius at the distance of 23°. About 5½° west of Sirius is *Mirzam*, of the second magnitude, in the foot of the Dog. Nearly due east from Orion, but less elevated above the horizon, is *Canis Minor*, or the Lesser Dog. The centre of this small constellation is situated about 5° north of the equinoctial, and midway between Gemini and Canis Major. It is distinguished by the bright star named *Procyon*, which

signifies "before the Dog." About 4° to the northwest is *Gomelza*, a star of the third magnitude. Procyon, at the time supposed, appears nearly due east from Betelguese, at the distance of about 26°. The head of *Hydra* lies immediately to the east of Procyon; but *Alphard*, or *Cor Hydræ*, the principal star of this constellation, is not risen at the time supposed. A little to the north of the eastern point of the compass, and at a very small elevation above the horizon, is *Regulus*, a star of the first magnitude, in the constellation Leo, which is the *fifth* sign, and the sixth constellation of the zodiac.

Turning our faces towards the northeast, *Ursa Major*, or the Great Bear, is the most striking constellation that meets the eye. The two pointers, *Dubbe* and *Merak*, appear uppermost, and point westward to the Pole-star; while the stars forming the tail seem to hang downward from the square of this constellation. As the night advances, this group of stars rises higher in the heavens, till, about three in the morning, they approach near the zenith. *Ursa Minor*, or the Lesser Bear, is seen *below* the pole, the square of which being a little to the eastward of the meridian. Directly below the Great Bear, at a very small elevation above the horizon, and in a direction N.E. by N., is *Cor Caroli*, a star of the second magnitude, in *Chara*, one of the Greyhounds. North by east of Aldebaran, at the distance of 30°, is the bright star *Capella*, in *Auriga*.

Directing our view a little to the west of the meridian, we perceive the constellation *Aries*, which is immediately to the westward of the Pleiades, and nearly at the same altitude. Above 2000 years ago, in the days of Hipparchus, this constellation occupied the first sign in the zodiac, into which the sun entered about the 21st of March; but as, in consequence of the *precession of the equinoxes*, the constellations gain about 50″ on the equinox every year, they have now advanced in the ecliptic nearly 31° beyond it, or somewhat more than a whole sign; so that the constellation *Pisces* now occupies the same place in the zodiac that Aries did 2000 years ago, while the *constellation* Aries is now in the *sign* Taurus, Taurus in Gemini, &c., so that Aries, though the *first* sign, is the *second* constellation of the zodiac. It is situated next east of Pisces, and midway between the *Triangles* and *Musca* on the north, and *Cetus*, or the Whale, on the south. It

is distinguished by two bright stars in the head, distant from each other about 4°, the brightest being a little to the east or northeast of the other, being about 25° west of the Pleiades, and 19° south of *Almaack*, in the foot of Andromeda. North by east from Aries is *Musca*, or the Fly, which consists of four or five stars, chiefly of the third and fourth magnitudes, very near to each other. It is situated between the first star of Aries and the Pleiades, but a little higher than either. North by east from the Fly, at the distance of about 15°, and at 20° north by west of the Pleiades, and at a higher elevation, is the head of *Medusa*, the principal star of which is Algol, which regularly varies in its lustre. (*See* p. 96.) West by north from Medusa is *Andromeda*, one of the principal stars of which is *Almaack*, at the distance of 12° west by north of Algol. West of Almaack, at the distance of 12°, is *Merach*, both of them stars of the second magnitude. If the line connecting Almaack and Merach be prolonged 8° farther west or southwest, it will reach *Delta*, a star of the third magnitude in the left breast.

West from Andromeda, and a little to the south, is *Pegasus*, or the Flying Horse, which is distinguished from the other constellations by four bright stars of the second magnitude, forming a square, which is generally termed *the Square of Pegasus*. The northernmost star, which is the brightest of three that form a kind of triangle, is *Scheat*, whose N. declination is 26½°. *Markab* is situated 13° south of Scheat, and at the time supposed is nearly due west, and about 22° above the western point of the horizon. These two stars form the *western* side of the square. East from Markab, at the distance of 16½°, is *Algenib*, and 14° north of Algenib is *Alpheratz*; which two stars form the eastern side of the square. Scheat and Alpheratz form the *northern*, and Markab and Algenib the *southern* sides of the square. Alpheratz constitutes a part of the head of Andromeda, but it is also considered as connected with Pegasus. About 26° north of Andromeda is *Cassiopeia*, midway between it and the Pole-star. It passes the meridian nearly in the zenith about the 22d of November. At this time it is between 20° and 30° west of the meridian. (*See* p. 26 and 84.) The star *Caph*, in this constellation, along with Alpheratz and Algenib, are situated on the *prime meridian* which passes through the first point of Aries, from which the right ascensions of all the heavenly bodies are meas-

ured. The line connecting these stars forms an arc of the *equinoctial colure*, which passes through the vernal equinox, and across which the sun passes on the 21st of March. When we say that the sun, or a star, or a planet is in so many degrees of right ascension, we mean that it is situated, or has moved *eastward* so many degrees from this great circle. Northwest of Cassiopeia is *Cepheus*, at the distance of about 25°, the head of which is in the Milky Way, and may be known by three stars of the fourth magnitude in the crown, forming a small acute triangle about 9° from *Alderamin*, a star of the third magnitude in the left shoulder.

Next to Cepheus, on the west, is *Cgynus*, or the Swan; the principal stars of which are distinguished as forming the figure of a large *cross*, the upright piece of which lies along the Milky Way. The most brilliant star in this constellation is *Deneb* Cygni, of the first magnitude, which is at this time in a direction nearly northwest, and 25° above the horizon. West from Deneb, at the distance of 10° or 11°, is *Delta*; and the line prolonged about 15 degrees farther leads to the bright star *Vega*, the principal star in *Lyra*, which is then about 6° above the horizon in a direction northwest by north. North by east of Lyra is the head of *Draco*, distinguished by four stars separate from each other by intervals of 3°, 4°, and 5°. The one to the south, or nearest Lyra, is *Etanim*, or γ Draconis, which Dr. Bradley fixed upon in his attempt to determine the annual parallax. At this time it is 16° above the horizon, in a direction N.N.W. About 4° to the north of it is *Rastaben*, both of them stars of the second magnitude. Turning our eyes again towards the southern part of the meridian, we behold the head of *Cetus*, or the Whale, about 20° S. E. of Aries, and about 24° S. by W. of the Pleiades. It is distinguished by five stars, 4° or 5° asunder, which form a figure resembling a regular *pentagon*. The brightest of these stars, which is the easternmost, and of the second magnitude, is *Menkar*, which makes an equilateral triangle with *Arietis* and the Pleiades, being distant from each about 23½°. About 14° southwest of Menkar is *Mira*, or the Wonderful Star, which is found to vary its apparent size from a star of the second or third, to one of the sixth or seventh magnitude. (*See* page 94.) Northwest of the head of Cetus and west of Aries is the constellation *Pisces*, or the Fishes, one of the signs of the Zodiac, in which there are no remarkable stars,

most of them being of the third, fourth, and inferior magnitudes.

Such is a general outline of the heavens as they appear about the beginning of January.

General Appearance of the Heavens on the 1st of March, at 9 o'clock P.M.

At this period of the year, at 9 P.M., several of the constellations which were seen in the beginning of January have disappeared, such as Pegasus, Pisces, and others. Others, which are still visible, appear in other quarters of the heavens; and some stars and constellations which were then below the horizon have risen to a considerable elevation above it. Orion is now in the southwest quarter of the heavens; the Pleiades, instead of being on the meridian, are due west, at an elevation of 34° above the western point of the horizon; the bright star Sirius is to the west of the meridian, in a direction S.S.W.; Canis Minor and Procyon are a few degrees to the west of the meridian; Castor and Pollux, directly north of Procyon, have likewise passed the meridian; Capella is seen at a high elevation, 30 degrees west of the zenith; Menkar, in the head of the Whale, is within a few degrees of the western horizon; Aries is likewise near the western horizon; and Cassiopeia is in a northwesterly direction, and at a lower altitude than in January; Deneb, in the Swan, is very near the horizon, a little to the west of the north point; Vega, in the Lyre, is just rising at a short distance to the east of it; the head of Draco is in a N.N.E. direction, about 18° above the horizon; the Great Bear is at a higher elevation than in January, and the Pointers in a direction N.N.E.; and Cor Caroli appears in a direction east by north, about midway between the zenith and the horizon.

The following constellations, among others, now appear, which were under the horizon in January: *Hydra*, the largest star in which is *Alphard*, or Cor Hydræ. It is at this time in a direction S.S.E., about 28° above the horizon. It may be distinguished from this circumstance, that there is no other considerable star near it. It is 23° S.S.W. of Regulus. The constellation *Leo*, which was only partly visible in January, now appears in its splendour towards the eastern part of the sky. Regulus, one of its largest stars, situated within half a

degree of the ecliptic, is distinguished as being the largest and lowest of a group of five or six stars, which form a figure or curve somewhat resembling a *sickle*. East of Regulus, at the distance of 25°, is *Denebola*, in the Lion's tail, which appears nearly in an eastern direction 35° above the horizon. East from Leo is the constellation *Virgo*; but all the stars connected with it have not at this time risen above the horizon. It is situated midway between Coma Berenices on the north and Corvus on the south. *Coma Berenices*, which consists of a cluster of small stars, is in a direction nearly due east, and about midway between the zenith and the horizon. East by north of this cluster, at a low elevation, is Bootes, the principal star of which is *Arcturus*, of the first magnitude. It is at this time in a direction east by north, 14 degrees above the horizon. Farther to the north, and at a lower elevation, is *Corona Borealis*, or the Northern Crown, the principal star in which is called *Alphacca*, of the third magnitude, and 11° east by north of *Mirac*, or *ε* Bootes. This constellation is distinguished by its six principal stars, which are so placed as to form a circular figure, somewhat resembling a wreath or crown.

General Appearance of the Heavens on the 1st *of May, at* 9 P.M.

At this period several of the more splendid constellations which adorn our nocturnal sky during winter have disappeared. Orion is nearly hidden beneath the western horizon, and only the bright star of Betelguese can be faintly seen, as it is about to descend below the western point of the horizon. Aries has completely disappeared; Caput Medusæ, Taurus, the Pleiades, and Aldebaran, are just verging on the borders of the northwestern horizon, and are scarcely visible; and the brilliant star Sirius has completely disappeared from the nocturnal sky. The Head of Hydra, with Alphard, its principal star, are in a southwesterly direction; Canis Minor and Procyon are in a direction W.S.W., considerably to the west of Alphard, but nearly at the same altitude. North of Procyon, at a considerable distance, are Castor and Pollux, about midway between the zenith and the western point of the horizon. At a considerable distance to the northwest of these is Capella, considerably nearer the northwestern horizon than the zenith. Cassiopeia appears very low in altitude, near the northern quarter of the heavens; and the Great Bear appears near its

most elevated position, not far from the zenith, the two pointers pointing nearly directly downward to the Pole-star, while at the same hour in November they point almost directly upward. Regulus is about 22° west of the meridian, at a considerable elevation; Denebola, in the same constellation (the Lion), is just on the meridian, at a little higher altitude than Regulus. Arcturus is seen in a direction E.S.E., at a very considerable elevation, and 26° northwest of it is Cor Caroli, not very far from the zenith. The stars in the Northern Crown appear due east, midway between the zenith and the horizon. The brilliant star *α* Lyræ appears near the northeast, about 23½° above the horizon. The Swan is near the N.N.E. quarter of the sky, and one of its principal stars, Deneb, is about 14° above the horizon. The principal stars in Draco appear elevated 20° above *α* Lyræ, and nearly in the same direction.

The principal constellations which were formerly invisible are, the southeastern portion of *Virgo*, *Libra*, *Taurus Poniatowski*, *Serpentarius*, and *Hercules*. These constellations appear near the eastern and southeastern portions of the sky. The bright star of the first magnitude, *Spica Virginis*, which was below the horizon in March, is now elevated 24°, and may be seen in a direction S.S.E. It is 35° southeast of Denebola, and about the same distance S.S.W. of Arcturus; three stars of the first magnitude, which form a large equilateral triangle, pointing to the south. A similar triangle, pointing to the north, is formed by Arcturus, Denebola, and Cor Caroli. The principal star in Hercules is *Ras Algethi*; and *Ras Alhague*, 5° from it, in the head of Ophiuchus, may be seen nearly due east, at a small elevation above the horizon, Ras Algethi being the brightest and the highest. Libra is situated to the south of the *Serpent* and to the east of Virgo. Its two brightest stars are of the second magnitude; the one is named *Zubeneschamali*, 21° east of Spica Virginis, but at a much lower altitude; the other is called *Zubenelgemabi*, about 9½° above the other, towards the northeast. At this time they appear in the southeast quarter of the heavens, at no great elevation above the horizon. The constellation *Serpens* lies between Corona Borealis and Libra. Its principal star is of the second magnitude, and named *Unuk*; it may be known by being nearly in the middle between two smaller stars, the lower one being 2½, and the upper 5½ degrees from

it. It is in a direction E.S.E., and about 24 degrees above the horizon.

Aspect of the Heavens on the 1st *of July, at* 10 P.M.

As the twilight at this season is too strong to admit of particular observations at 9 P.M., I have fixed on the hour of *ten* as the most proper time for perceiving the principal stars. Most of the southern constellations which were visible in January, and which are the most brilliant, have now disappeared; and those in the north are in positions in the heavens very different from those in which they appeared in winter. The Northern Crown, the Serpent, and Libra, are now to the west of the meridian; Arcturus is considerably to the west of the meridian, but at a high elevation; immediately below which, at a considerable distance, is Spica Virginis, very near the S.W. by W. point of the horizon. Cor Caroli appears north by west of Arcturus, at a considerable distance, and at a high altitude; immediately below which, at a considerable distance, and nearly due west, is Denebola. The Great Bear is now considerably west of the meridian, at a high altitude, the two pointers pointing *eastward* to the Pole-star. Castor and Pollux have just descended below the horizon near the northwest; and Capella, which never sets in this latitude, is very near the north point, only a few degrees above the horizon. Cassiopeia is near the northeastern quarter, at no great elevation, and α Lyræ is at a very high altitude to the east of the meridian; east of which, at a lower altitude, is Deneb, one of the principal stars in the Swan. The four stars forming the *Square of Pegasus* are now seen a little to the north of the E. point, in a position nearly opposite to that in which they appeared in January. The star *Antares*, in Scorpio, of the first magnitude, is past the meridian, at an altitude of only about 11°. Ras Algethi and Alhague are nearly on the meridian.

The constellation of *Aquila*, or the Eagle, which was formerly invisible, now makes its appearance in the southeast. *Altair*, its principal star, of between the first and second magnitude, is distinguished by being nearly in the middle between two stars of the third magnitude, each of them 2° distant from it in a line bearing S.E. and N.W. Altair is at this time about 37° above the southeastern horizon. Northeast of Aquila is the *Dolphin*, at the distance of 13° or 14°. It is a

beautiful little cluster of stars, consisting of about 18 in number, including five of the third magnitude, but none larger, which are so arranged as to form the figure of a diamond, pointing N.E. and S.W. It is sometimes known by the name of *Job's Coffin*. North and northwest of the Dolphin are *Sagitta* and *Vulpecula et Anser*, or the Fox and Goose; south of Aquila is *Capricornus*, and southeast of it *Aquarius*; but these last are more distinctly seen in the month of September. The Milky Way runs along with considerable brightness in the neighbourhood of Aquila, Vulpecula, Delphinus, and Cygnus.

Appearance of the Sidereal Heavens on the 1st of September, at 9 P.M.

At this time *Altair* is nearly on the meridian, at an altitude of 46½°, and *Vega*, or α Lyræ, is about 16° west of the meridian, in a direction north by west from Altair. Ras Algethi and Ras Alhague are west from Altair, nearly midway between that star and the southwestern point of the horizon. To the northwest of Vega is the head of Draco, at the distance of nearly 20°. Arcturus is in a position west by north, within 19° of the horizon. The Northern Crown is in a higher elevation than Arcturus, nearly due west, rather nearer the horizon than the zenith. Cor Caroli appears nearly N.W. by W. at 23° of altitude; and the Great Bear in a northwesterly direction, and at a lower altitude than formerly. To the east of the meridian, Capella is seen in a direction nearly N.N.E., at the altitude of 15°. East of Capella, at a little lower elevation, is *Menkalina*, or β Aurigæ, a star of the second magnitude. Cassiopeia appears in the northeast, about midway between the zenith and the northeastern horizon. The Square of Pegasus is in a direction east by south, and is in a much higher elevation than in July. The Dolphin is a few degrees east of the meridian, and N.E. of Altair, at an altitude of above 50°. Along the southern quarter of the heavens are the following constellations: Aries, in a direction east by north; Pisces, due east, and next to Aries on the west; Aquarius, to the west of Pisces, in a direction S.S.E.; Capricornus, west from Aquarius, nearly in the south; Sagittarius and Sobieski's Shield, in a southwesterly direction, and Scorpio, which lies still farther to the west. Most of these constellations, except Aries and Pisces, are at a low altitude.

Appearance of the Heavens on the 1st November, at 9 P.M.

About this time the winter constellations begin again to make their appearance in our hemisphere. The centre of the Square of Pegasus is at this season and hour nearly on the meridian; the stars Scheat and Markab, of which Scheat is the uppermost, appear on the west of the meridian, and Alpheratz and Algenib on the east. Turning our eyes to the western part of the heavens, we see the *Southern Fish*, a little to the west of the south, and its principal star, Fomalhaut, several degrees to the west of the meridian, at a very low altitude. To the west is Capricornus, and to the northwest Aquarius. Aquila, with its principal star Altair, is in a direction west by south, at about 23° above the horizon. Deneb Cygni is at a very high elevation, about 20° west from the zenith, and *a* Lyræ 26° northwest of it, in a direction W.N.W., at a much lower elevation. North by west of Lyræ are the two stars in the head of Draco, *Etanin* and *Rastaben*, about 4° apart. Ras Algethi and Ras Alhague are nearly due west, at a very small elevation above the horizon. The centre of the Great Bear is nearly due north, and at its lowest elevation, the stars in the tail being to the west, and the two pointers a little to the east of the northern part of the meridian, pointing upward. Turning our view to the eastern quarter of the sky, we behold Aries in a southeasterly direction, next to Pegasus, and at a pretty high elevation. South by east of the first star in Aries is Menkar in the head of the Whale, in a direction S.E. by E., about 26° above the horizon. Northwest of the first star in Aries is Mirach, and north by east Almaack, at a higher elevation, both of them in Andromeda. Near the north quarter is Capella, about midway between the zenith and the horizon. The Pleiades are seen nearly due east, followed by the ruddy star Aldebaran, at a lower elevation. Below Aldebaran, and to the southeast, the head and shoulders of Orion begin to make their appearance, Bellatrix being 4° or 5° above the horizon, and Betelgeuse a little lower. Cassiopeia is near the zenith, a little to the east of the meridian, and Castor and Pollux, in Gemini, are in a direction northeast, just a little above the horizon. At this time the *equinoctial colure* is only a few degrees to the east of the meridian, and the three stars *Caph*, in Cassiopeia, and *Alpheratz* and *Algenib*, in Pegasus, which lie in the line of its

curve, may now be distinctly perceived. Caph is at the highest altitude of the three, and its distance from Alpheratz is about double the distance between Alpheratz and Algenib. If a line connecting these three stars be produced northward, it will terminate in the pole.

The above brief sketches may enable the young observer to trace the principal stars and constellations by a few observations at different seasons of the year. The altitudes here expressed are stated in reference to places about 52° north latitude; but, by making certain allowances, corresponding to the latitude of the observer, the relative positions of the stars will appear nearly the same as here represented, particularly if the difference of latitude does not much exceed 10 degrees. It should be carefully remarked, that the *bearings* of one star from another, as here given, are strictly true only when the star from which the bearings are given is *on or near the meridian*.—(See note, p. 184.)

As a farther assistance to the astronomical tyro in distinguishing the stars, I have drawn up the following list of stars, chiefly of the first and second magnitudes, stating *the periods of the year* when they come to the meridian, or due south, *at nine o'clock in the evening*.

Caph, in Cassiopeia, and *Alpheratz* and *Algenib*, in Pegasus, come to the meridian on *the 10th of November*, at nine o'clock in the evening. Caph is near the zenith, and the other two at a considerably lower elevation. At this time Capella appears towards the northeast; the Pleiades, Aldebaran, and Orion in the east; Deneb, in Cygnus, in the northwest; Lyra, west-northwest; and Altair, in Aquila, west by south.

Arietis, or the first star of Aries, comes to the meridian on *the 5th of December*. The same stars noticed in the preceding instance are still visible, but those on the east of the meridian have risen to a higher altitude, and those on the west have descended to a lower elevation than on Nov. 10. Castor and Pollux are at this time seen towards the northeast, and Procyon a very little above the eastern point of the horizon.

Menkar, in the head of the Whale, arrives at the meridian on *the 21st of December*, and at the same time the variable star *Algol*, in Medusa's head, which is 37° due north o

Menkar. Altair has now disappeared from the west, and Sirius is seen at a small elevation in the southeast.

The *Pleiades* pass the meridian on *the 1st of January*, and *Aldebaran* on the 10th. When Aldebaran is due south, Capella is north by east of it near the zenith; Cor Caroli, at a low altitude near the northeast; Lyra, near the horizon N. by W.; Regulus, in the east; and the head of Hydra, east by south.

Bellatrix, in Orion, passes the meridian on *the 21st of January*. Nearly at the same time, Capella and β Aurigæ are on the meridian. These three stars are nearly equidistant in a line running north and south.

Castor and *Pollux*, and *Procyon*. These stars pass the meridian nearly at the same time, on *the 24th of February*. Pollux and Procyon culminate nearly at the same instant, and Castor about 11 minutes before them, at which time Procyon is 23° south of Pollux. Orion is then in a southwesterly direction; Aldebaran, midway between the meridian and the western horizon; Menkar, W. by S., at a small elevation; Sirius, S. by W.; and Capella to the west of the zenith. On the east of the meridian, Regulus is S.E.; Denebola, E.; Cor Caroli, E.N.E.; immediately below which, near the horizon, is Arcturus.

Præsepe, in Cancer, a small cluster of stars, just perceptible to the naked eye, like a nebula, approaches the meridian about *the 3d of March*, at an altitude of about 60°. They are N.E. of Procyon, and S.E. of Pollux. (*See* p. 162, 163.)

Regulus, in Leo, passes the meridian on *the 6th of April*. At this time, *Alphard*, in Hydra, is past the meridian S. by E. from Regulus; Procyon, S.W.; Sirius, S.W., near the horizon; Orion, very low in the west; Algenib, in Perseus, Algol, Capella, &c., towards the N.W. On the east, Denebola appears E. from Regulus; Spica Virginis, S.E., at a low altitude; Cor Caroli, E., at a high altitude: Corona Borealis, E. by N.; and Lyra, at a low altitude, N.E. by N. The Great Bear, at a high altitude, approaching the zenith, and Cassiopeia, at a low altitude towards the north.

Denebola, in Leo, culminates on *the 3d of May*, at an altitude of 43°. Regulus is 25° west of it, and *Phad*, in the square of the Great Bear, is 39° N. of it. It forms with these two a large right-angled triangle, the right angle be at Denebola. It is nearly on the meridian with *Phad*.

er stars then visible are, Procyon, W. by S.; Capella., N.W.; Arcturus, E.; Spica Virginis, S.S.E.; Lyra, N.E., &c.

Coma Berenices, a beautiful cluster of small stars, but scarcely distinguishable by moonlight, is on the meridian on *the 13th of May*. (*See* p. 161.)

Spica Virginis comes to the meridian on *the 23d of May.* Stars visible on the west, Capella, Castor and Pollux, and Procyon, near the western point. On the east, Lyra, Arcturus, Ras Algethi, Ras Alhague, and Altair, near the eastern horizon. Near the meridian to the west, Cor Caroli, Alioth and Mizar, in Ursa Major.

Arcturus is on the meridian on *the 23d of June.* The principal stars in Libra culminate at a lower altitude about the beginning of July.

Corona Borealis is on the meridian about *the 1st of July.* Its principal star is eleven degrees east of ε Bootes.

Antares, in Scorpio, passes the meridian on *the 10th of July*, at a very low altitude.

Ras Algethi, in Ophiuchus, and *Ras Alhague*, in Hercules, 5° apart, culminate about *the 28th of July*, nearly at the same time as the head of Draco.

Vega, or *a* Lyræ, culminates on *the 13th of August.* To the west of it, at a great distance, is Arcturus, and to the northwest, Cor Caroli. Capella is N. by E., at a low altitude; Altair, S.S.E.; and Deneb Cygni, E., at a high altitude.

Altair, in Aquila, is at the meridian about *the 30th of August*, at an altitude of about 46½°.

Arided, or *Deneb Cygni*, is on the meridian on *the 16th of September*, at an altitude of 82½°. At this time Arcturus is W.S.W., near the horizon; Lyra and *Etanin*, in Draco, west from the meridian, but in a high elevation; Cor Caroli, N.W., at no great elevation; Hercules, S.W., midway between the meridian and the horizon; Altair, a little distance west of the S.; and the Dolphin on the meridian; the square of Pegasus in a southeastern direction, Aries in the east, and Capella towards the northeast.

All the stars specified above, at the periods of the year stated, pass the meridian (or culminate) *at nine o'clock in the morning.* Therefore, if at any one of the periods here specified, or a few days before or after it, an observer, at nine o'clock P.M., observe the principal star or stars near the meridian, he can scarcely be at a loss to recognise them, as well

as some of the other principal stars and constellations on the east and west of the meridian, which are also specified in the above descriptions. A person can never become familiar with the more prominent stars, the relative position of the different constellations, and the general aspect of the heavens, *without actual observations*. Even the delineations on the celestial globe will not convey an accurate and impressive conception of the scenery of the heavens, unless the study of these delineations be accompanied with frequent surveys of the heavens themselves. It is hoped the preceding descriptions will afford some assistance to those young observers and others who wish to contemplate the sublime objects of creation with their own eyes.

N.B. In the above and the following descriptions of celestial phenomena, *altitude* signifies the height of the star or planet above the horizon; S.S.E., south-southeast; N. by E., north by east, &c. *Degrees* are marked thus °, *minutes* ′, *seconds* ″: thus, 54° 27′, 35″, expresses fifty-four *degrees*, twenty-seven *minutes* of a degree, and thirty-five *seconds*. Every degree contains 60 minutes, every minute 60 seconds, &c. When a heavenly body is said to *culminate*, the meaning is, that it has arrived at the highest point of its course, or its passage over the meridian. The term is derived from the Latin word *culmen*, the top or summit. An *occultation* signifies the obscuration of a star or planet by the interposition of the moon or of another planet. *Conjunction* is when two or more stars or planets are in the same part of the heavens; and *opposition*, when they are 180° asunder, or in opposite parts of the heavens.

PHENOMENA OF THE PLANETS FOR THE YEARS 1840 AND 1841.

I. POSITIONS, ETC., OF THE PLANETS FOR 1840.

1. *The Planet Mercury*.

THIS planet can be distinctly seen by the naked eye only about the time of its greatest elongation; and to those who reside in high northern latitudes it will scarcely be visible

even at such periods, if it be near the utmost point of its *southern* declination.

The following are the periods of its greatest elongation for 1840: On the 8th of January it is at its *western* elongation, when it is 23° 19′ west of the sun, and will be seen in the morning near the southeastern part of the horizon; but as it is then 21° 45′ in southern declination, and this declination every day on the increase, its position at that time will not be favourable for observation. Its next greatest elongation is on the 20th of March, when it will be 18½ degrees *east* of the sun, and be seen in the evening soon after sunset. This will form one of the most favourable opportunities of perceiving this planet by the naked eye, or by means of a small opera-glass. Its declination being above nine degrees north, and on the increase, it will be distinctly seen for about ten days, namely, from the 16th to the 26th of March, a little to the north of the western point of the horizon, not far from the point at which the sun sets at that period. On the 5th of May it will again reach its greatest *western* elongation, when it will be seen in the morning before sunrise. Its declination is then 4½ degrees north, and western elongation from the sun 26° 18′. At this period, about four o'clock in the morning, it may be seen for more than three weeks, namely, from about the 25th of April to the 20th of May. Its direction will be nearly due east. This would form the most favourable opportunity of viewing this planet, were it not that the strong twilight at this season has a tendency to overpower its light.

In the month of July, if the long twilight do not prevent, there will be another favourable opportunity of inspecting this planet. During the whole of this month, Mercury will be at a considerable distance from the sun; but the best time for observation will be from the middle till the end of the month, as the twilight will then be less intense. It arrives at the point of its greatest *eastern* elongation on the 18th, when it is nearly 27° from the sun, and will be seen in the evening a little to the north of the western point of the compass, about forty minutes after sunset, or nearly nine o'clock P.M. Its next greatest *western* elongation will be on the 1st of September, when it is 18° 5′ west of the sun. At this period it may be seen in the morning before five o'clock, in a direction nearly east by north, from the 27th of August to the 5th of September. On the 12th of November it is at its next *east-*

ern elongation, when it will be seen after sunset near the southwestern point of the horizon; but as its southern declination is at this time about 25 degrees, it will descend below the horizon nearly at the same time with the sun. The next elongation is on the 21st of December, when it is 21° 50′ *west* of the sun, and will be seen in the morning between seven and eight, near the southeast quarter of the horizon.

The periods most favourable for detecting this planet in the *evenings* are, March 20th and July 18th; and in the *mornings*, May 5th and September 1st. During the interval of a week or ten days, both before and after the time of its greatest elongation, and sometimes for three or four weeks in succession when in high north declination, this planet may generally be seen in a clear sky when in such favourable positions as those now stated. In those regions of the globe which lie south of the equator, the planet will be in the most favourable position for observation when in *south* declination.

2. *The Planet Venus.*

This planet, like Mercury, is seen alternately, in the evening towards the western quarter of the heavens, and in the morning towards the eastern quarter. In its lustre it exceeds all the other stars and planets, and its brilliancy is such that it can scarcely be mistaken by any observer when its position in the heavens is pointed out.

Venus will be seen only in the morning from the beginning of the year till the end of July. During the months of January, February, and March, it will be seen before sunrise, chiefly in the *southeastern* quarter of the heavens. Throughout April, May, June, and July, it will be seen in the eastern and *northeastern* parts of the heavens. During the whole of this period it will appear, when viewed with a telescope, either as a half moon or with a gibbous phase. Its *superior* conjunction with the sun happens on the morning of the 25th of July, after which it becomes an *evening* star; but it will not be much noticed by common observers till about the beginning or middle of September, on account of its proximity to the sun. From this period it will continue to be seen in the evening chiefly in the *southwestern* part of the sky, at a low elevation, till the end of the year. On the whole, this planet will not be very conspicuous during 1840, either to the eye of a common observer or for telescopic observation.

From the beginning of September to the end of December it will exhibit a gibbous phase, like the moon about three or four days before the full.

Venus will be in conjunction with Saturn on the 22d of January, at 2^h 8′ P.M., when it will be 57′ north of Saturn. It will be in conjunction with Mars on the 16th of June, at sixteen minutes past three in the morning, when Mars will be 46′ north of Venus; and it will be in conjunction with Jupiter on the 22d of October, at 8^h 34′ P.M., when it will be 1° 6′ south of that planet.

3. *The Planet Mars.*

This planet will not be very conspicuous during this year, on account of its great distance from the earth, and its proximity to that part of the heavens in which the sun appears. It is in conjunction with the sun on the 4th of May, after which it will be a considerable time before it become conspicuous to the unassisted eye. Throughout the months of August and September, and the latter part of July, it will be seen early in the morning, before sunrise, near the northeastern quarter of the heavens. From September till the end of the year, it will appear somewhat more conspicuous, but not exceeding in apparent size a star of the third magnitude. On the 1st of October it comes to the meridian at six minutes past nine in the morning, at an altitude of 52¾° above the southern horizon. On the 1st of November it passes the meridian at fourteen minutes past eight in the morning, at an altitude of about 46°; and on the 1st of December it transits the meridian at nineteen minutes past seven in the morning, at an altitude of 39¾°. At this time (1st of December) it rises nearly due east about one in the morning, and will be pretty distinguishable, on account of its ruddy aspect, about an hour before sunrise.

4. *The Planets Vesta, Juno, Ceres, and Pallas.*

These planets are not perceptible to the naked eye. The best time for observing them with telescopes is when they are at or near the period of opposition to the sun, when they are nearest the earth. Even then it will be sometimes difficult to detect them without the assistance of transit or equatorial instruments.

Vesta will be in opposition on the 18th of May, when it will pass the meridian at midnight, at an elevation above the

horizon of 27° 34½′. Its right ascension is then 15^h 51′ 55½″, and its declination 10° 25½′ south. This planet will be in conjunction with the star ξ Libræ on the 1st of March, at twenty-seven minutes past five in the morning, the star being 55′ north of Vesta; it will likewise be in conjunction with the same star on the 15th of May, at noon, when the star will be 29′ south of the planet. On the 19th of July, at six in the morning, it will be in conjunction with γ^1 Libræ, when the star will be only one minute south of the planet, so that they will both appear in the same field of the telescope. On the 26th of August, at nineteen minutes past eight A.M., it will be in conjunction with ν Scorpio, when the star will be only 11′ south of Vesta. On September 3d, at eight in the evening, it will be in conjunction with ψ Ophiuchi, the star 11′ north of the planet. On the 2d of October, at half past one in the morning, it is in conjunction with Sa urn, being 1° 2′ south of that planet; and on the 6th of December, at ten minutes past one in the morning, it is in conjunction with Venus, Vesta being only 11′ north of Venus.

Pallas will be in opposition to the sun on the 5th of July, at thirty minutes past nine in the evening. Right ascension, 18° 44′ 52″; north declination, 22° 11′ 37″. It will pass the meridian about midnight, at an altitude of about 60° 11½′.

Ceres will be in opposition July 17th, at six in the morning. Right ascension, 19° 54′; south declination, 30° 8′. It will pass the meridian at an elevation somewhat less than 8°.

Juno will not be in opposition to the sun during 1840.

That the best time for observing these bodies is at the period of their opposition, will appear from the following consideration: that they are between two and three times nearer the earth at the time of opposition than when near the period of their conjunction with the sun; for example, Vesta is 225 millions of miles distant from the sun, and, consequently, only 130 millions distant from the earth at the time of opposition; but at the conjunction it is the whole diameter of the earth's orbit = 190 millions of miles farther distant, that is, 320 millions of miles, which is a distance about two and a half times greater than when it is in opposition.

5. *The Planet Jupiter.*

During the months of January, February, March, and April, this planet will be seen chiefly in the morning. About the

beginning of February it will rise in a direction southeast by east, about half past one in the morning, and will come to the meridian at a quarter past six in the morning, at an elevation of about 22° above the southern horizon. On the 1st of March it will rise about eight minutes before midnight, and pass the meridian about half past four in the morning. On the 1st of April it will rise at forty-three minutes past nine in the evening, and pass the meridian at a quarter past two in the morning. It will be in opposition to the sun, and, consequently, nearest the earth, on the 4th of May, when it will rise between seven and eight in the evening. From this period till the middle of November, when it is nearly in conjunction with the sun, it will be visible as an *evening* star, when it will be seen at different periods, chiefly in the southeastern, the southern, and the southwestern parts of the heavens, at a comparatively low altitude; but it will not be much noticed by the naked eye after the end of September, on account of its southern declination, which, for a considerable time, will be gradually increasing. Towards the end of December it will again be seen in the morning near the southeastern quarter of the horizon. The best time for telescopic observations on this planet will be from the beginning of April till the beginning of September.

Jupiter will be in conjunction with the star α^2 Libræ on the 15th of May, at forty-three minutes past three in the morning, when the star will appear one degree south of Jupiter; and on the 27th of August, at a quarter past two in the morning, it will be in conjunction with the same star, when it will be 34′ below Jupiter. On the 21st of November, at 4^h 34′ P.M., it is in conjunction with the sun. On March 5th, at three in the morning, all the satellites of Jupiter will be on the *east* of the planet, when viewed with a telescope having an erect eye-piece, and *in the order of their distances from Jupiter*. The same phenomenon will happen on the 8th of June, at thirty minutes past eleven in the evening; on the 1st of August, at half past eight in the evening; on the 27th of August, at the same hour, but on the *west* of Jupiter; on the 20th of September, at seven P.M., on the *east* of Jupiter; and on the 16th of October, at six P.M., on the *west* of Jupiter.

This planet can scarcely be mistaken, even by a common observer, when the quarter of the heavens in which it is visible is known, as it is next to Venus in apparent magnitude and

splendour. It will appear most brilliant about the end of April and the beginning of May.

6. *The Planet Saturn.*

This planet was in conjunction with the sun on the 6th of December, 1839; and therefore it will not be before the month of February this year that it will be in a favourable position for telescopic observation. During the months of February, March, and April, it will be seen only in the morning before sunrise, in the southeastern quarter of the heavens, at a comparatively low altitude. On the 1st of February it rises at half past four in the morning, and comes to the meridian about half past eight, at an elevation of about 16½°. On the 1st of March it rises at forty minutes past two in the morning; on the 1st of April at forty-two minutes past twelve, midnight; and on the 1st of May, it rises at forty minutes past ten in the evening. It is in opposition to the sun on the 8th of June; after which it will be seen in the evening. During the greater part of the month of May, it will likewise be seen between ten in the evening and midnight, but at a low altitude. It will continue to be visible till the month of December, but it will be difficult to distinguish it after the month of October, on account of its low altitude and its proximity to the sun. It arrives at the point of its conjunction with the sun on the 15th of December. The most favourable times and positions for taking telescopic views of this planet will be during the months of May, June, July, August, and September, especially when it is on or near the meridian. During the latter part of August and the months of October and November, about an hour after sunset, it will be seen towards the southwestern quarter of the heavens, at a comparatively small elevation above the horizon.

This planet is not distinguished for its brilliancy to the naked eye; but it exhibits a most striking and beautiful appearance through a telescope; more so than any other planet of our system. It appears of a dull leaden colour when viewed by the naked eye, and is not easily distinguished from a fixed star except by the steadiness of its light, never presenting a *twinkling* appearance as the stars do; and from which circumstance it may be distinguished from neighbouring stars. It will be in conjunction with the star *Rho* Ophiuchi on the 5th of June, at 51 minutes past 8 P.M., when the star will be

about half a degree north of the planet. It will likewise be in conjunction with the same star on the 27th of October, at 9^h 36′ P.M., when the star will be fifty-four minutes of a degree north of the planet. During this year the rings of Saturn will appear to the greatest advantage, the opening of these rings being then at their utmost extent. In the beginning of October, the proportion of the longer axis to the transverse axis of the rings is nearly as 35 to 16.

7. *The Planet Uranus.*

This planet is for the most part invisible to the naked eye. The best time for detecting it by means of a telescope is when it is at or near the period of its opposition to the sun, which happens this year on the morning of the 11th September. At that time it passes the meridian about midnight, at an elevation of about 32⅗° above the horizon. On the 1st of August it passes the meridian at forty minutes past two in the morning; on the 1st of October, at thirty-two minutes past ten in the evening; on the 1st of November, at twenty-seven minutes past eight; and on the 1st of December, at twenty-eight minutes past six, in the evening. Its right ascension, or distance from the first point of Aries at its opposition, September 11, is 23^h 18′; and its south declination, 5° 20′ 26″. It rises during the year at points a little to the southward of the eastern point of the compass. It is in conjunction with the moon on the 9th of January, at 2^h 17′ P.M., when it is 1° 27′ south of the moon. It is in conjunction with Mars on the 16th of February, at 11^h 33′ P.M., when Uranus is only nine minutes of a degree to the north of Mars; so that the two planets would be seen at the same time in the field of the telescope, were not both these bodies rather too near the sun at that time for distinct observation. It is in conjunction with the sun on the 6th of March, and with the moon on the 31st, when it is 2° 1′ south of the moon. It is in conjunction with Venus on the 6th of April, at seven in the morning, when it is 40′ north of Venus. On the 25th of May, at forty-five minutes past nine in the evening, it is in conjunction with the moon, when it is 2° 39′ south of that luminary. On the 15th of August, at 3^h 15′ P.M., it is again in conjunction with the moon, when it is 3° 9′ south of that luminary. On the 11th of September, at 8^h 42′ P.M., and on the 9th of October, at four in the morning, it is in conjunction with the moon, and in both cases it is then about 3° south of the moon.

N.B. In the preceding statements, the observer is supposed to be in 52° north latitude. In places a few degrees to the north or south of this latitude, a certain allowance must be made for the times of rising and the altitudes which are here specified. To those who reside in lower latitudes than 52°, the altitudes of the different bodies will be *higher*, and to those in higher latitudes the altitudes will be *lower* than those which are here specified. For example: when it is stated that Saturn comes to the meridian at an altitude of 16½°, this planet will pass the meridian of a place in 42° N. latitude at an altitude of 26½°, and the meridian of a place in 62° N. latitude at an altitude of only 6½°. There being 10° of difference in the latitude of the supposed places, the altitude of the heavenly body will be 10° higher in the one case, and 10° lower in the other.

II. POSITIONS OF THE PLANETS FOR 1841.

1. *Mercury.*

This planet is at its superior conjunction with the sun on the 5th of February, and at its greatest elongation on the 4th of March, when it is 18° 8′ *east* of that luminary; it will therefore appear as an *evening* star, in a direction nearly due west, a little above the horizon, after sunset, between six and seven in the evening. It arrives at its inferior conjunction with the sun on the 20th of March. Its next greatest *western* elongation happens on the 17th of April, when it is 27° 21′ west of that luminary. The planet will be seen about ten or twelve days before and after this time in an easterly direction, between three and four in the morning. Its next superior conjunction is on the 26th of May; and its next greatest *eastern* elongation on the 30th of June, when it is 25° 49′ east of the sun, and, consequently, will be visible in the evening, in a northwesterly direction, after sunset. This would form one of the most favourable opportunities of seeing this planet, as it is then in a high north declination, were it not that the strong twilight at this season prevents small objects in the heavens from being easily distinguished. Its next greatest elongation is on August 15th, when it is 18° 37′

west of the sun, when it will be seen in a northeasterly direction, about four in the morning. It is again at its greatest eastern elongation on the 25th of October, when it is nearly 24° east of the sun. It will be near the southwestern part of the sky about sunset; but its great southern declination at that period will prevent it from being easily distinguishable. On the 3d of December it will reach the point of its greatest western elongation, when it is 20½° west of the sun; when it may be seen for a week before and after this time, about seven in the morning, in a direction a little to the north of the southeast point of the compass, at a low altitude.

2. *Venus.*

Venus will this year exhibit a more frequent and brilliant appearance to common observers than in 1840. It will be an evening star, first in the southwestern, next in the western, and afterward in the northwestern quarter of the heavens, during the months of January, February, March, April, and the beginning of May. During the greater part of January it will appear nearly in a southwesterly direction, and W.S.W. Throughout February it will appear nearly west, and west by north. Throughout March, April, and the beginning of May, it will be seen in a northwesterly direction, will be visible in a pretty high elevation above the western horizon, and will continue for the most part nearly three hours above the horizon after sunset. Its greatest brilliancy is about the 8th of April, when it appears in a crescent form. When viewed by the telescope in January it will present a *gibbous* phase, like the moon four or five days before or after the full. In February and March it will be in the form of a *half moon*; in April and the beginning of May it will assume the figure of a crescent; this crescent will appear more and more slender, but more expansive, till within a few days of its inferior conjunction with the sun, which takes place on the 15th of May, about one in the morning. After this period this planet will be seen by the naked eye only in the morning before sunrise, in an easterly and a northeasterly direction, till the end of the year; but with an equatorial telescope it may be distinctly seen every clear day, even at noon, during its whole course from one conjunction to another, with the exception of only two or three weeks in the course of nineteen months. Its greatest brilliancy, after passing its inferior conjunction, is

about the 20th of June; previous to which it will appear as a crescent, and will afterward gradually assume a half moon and a gibbous phase.

Venus, in its course throughout the year, will pass very near some of the other planets and some of the fixed stars. The following table exhibits the times and circumstances of those conjunctions in which Venus makes the nearest approach to some of these bodies:

Time of Conjunction.			h. m.		Star in Conjunction.	Relative Position.
1.	Jan.	12 . . .	11 11	A.M.	σ Aquarii	* 0°15′N
2.	—	25 . . .	1 25	A.M.	Uranus	Ura. 0 4 N.
3.	Feb.	18 . . .	7 46	A.M.	ϵ Piscium . . .	* 0 3 N.
4.	Mar.	22 . . .	0 11	A.M.	ϵ Arietis	* 0 8 N.
5.	April	7 . . .	6 56	A.M.	*e* Pleiadum . . .	* 0 51 S.
6.	—	23 . . .	6 31	P.M.	The Moon	Ven. 0 59 N.
7.	July	12 . . .	7 43	A.M.	δ^1 Tauri	* 0 11 S.
8.	—	12 . . .	3 52	P.M.	δ^2 Tauri	* 0 20 S.
9.	—	13 . . .	1 4	A.M.	δ^3 Tauri	* 0 6 N.
10.	—	24 . . .	3 40	A.M.	*m* Tauri	* 0 46 S.
11.	—	31 . . .	11 15	A.M.	ζ Tauri	* 0 57 N.
12.	Aug.	4 . . .	9 25	A.M.	χ^1 Orionis	* 0 14 S.
13.	—	6 . . .	1 26	P.M.	χ^5 Orionis	* 0 30 S.
14.	—	12 . . .	3 53	A.M.	ν Geminorum . .	* 0 35 S.
15.	—	19 . . .	7 12	P.M.	ζ Geminorum . .	* 0 4 S.
16.	Sept.	10 . . .	2 45	A.M.	δ Cancri	* 0 38 N.
17.	—	12 . . .	7 50	A.M.	The Moon	Ven. 0 21 N.
18.	—	28 . . .	0 13	A.M.	α Leonis	* 0 5 S.
19.	Oct.	3 . . .	7 35	A.M.	ρ Leonis	* 0 43 S.
20.	—	10 . . .	9 2	A.M.	χ Leonis	* 0 15 N.
21.	—	13 . . .	9 56	P.M.	σ Leonis	* 0 29 N.
22.	—	26 . . .	9 42	P.M.	η Virginis	* 0 14 S.

In the above table, the first column states the time of conjunction of the star or planet with Venus; the second column contains the name of the star or planet; and the third, the distance and position of the star or planet from Venus. N. denotes that the star is north of Venus, and S. that it is south. A.M. denotes before twelve at noon; and P.M. afternoon. In those conjunctions marked Nos. 1, 2, 3, 4, 8, 9, 12, 15, 17, 18, 20, 22, the star and the planet will be seen in the same field of view of the telescope; and although the observation should require to be made in the daytime, the star may probably be distinguished if the telescope have a great

magnifying power. The conjunction of Venus with *Uranus*, on the 25th of January, at twenty-five minutes past one in the morning, will afford an opportunity to amateur observers of observing this latter planet, which is invisible to the naked eye. Although both these bodies will be set to the inhabitants of Britain before the conjunction take place, yet they will be both seen in the same field of the telescope, between six and eight o'clock on the preceding evening, and they will not be far distant on the evening immediately succeeding the conjunction. At New-York, Philadelphia, Boston, and other parts of the United States, these planets will be seen about an hour or an hour and a half before the time of conjunction, Uranus appearing very near to Venus, and uppermost, when viewed with a telescope having an erect eyepiece.

N.B. All the above, and the preceding and following statements, are calculated for the meridian of Greenwich, and are expressed, not in *astronomical*, but in *civil* time.

3. *Mars*.

During this year this planet will make a conspicuous appearance, and be seen in its brightest lustre; but its declination being *south* throughout the year, it will not rise to so high an altitude, nor remain so long above the horizon, as in some former years. During the months of January, February, and March, it will be seen only or chiefly in the morning, in a southeasterly direction. In the beginning of January it will appear nearly in a direction east by south soon after the time of its rising. On February the 1st it comes to the meridian about five in the morning, at an altitude of about 29°; and on March the 1st, at thirty-seven minutes past three in the morning, at an altitude of 27°. About the middle of March it will rise about half past nine in the evening, and may be seen about an hour or two afterward near the southwest quarter of the heavens. From this period it will be seen in the evening till the end of the year; but as its distance from the earth will rapidly increase after the months of August and September, and as it is then in a high degree of south declination, it will not be much noticed by common observers during October, November, and December. On the 18th of April, about two in the morning, it arrives at the point of its *opposition* to the sun, when it is nearest the earth, when it appears

with a full, enlightened hemisphere, and when it affords the best opportunities for telescopic observation. It will be most conspicuous this year, in the evening, during March, April, May, June, July, and August, and will be distinguished from surrounding stars by its *ruddy* appearance. During the months of July, August, and September, it will be seen chiefly near the southwestern portion of the sky. On the 11th of March it is *stationary;* that is, appears without any apparent motion; after which, its motion is *retrograde*, or contrary to the order of the signs of the Zodiac, and continues till the 29th of May, when it is again stationary; after which its motion is *direct*, or according to the order of the signs.

The planet Mars will be in conjunction with θ Virginis on the 1st of January, at thirty-two minutes past four P.M., when the star will be 17′ south of the planet. It will be in conjunction with κ Virginis on the 4th of April, at eight in the morning, when the star will be 49′ north of Mars. It will be in conjunction with α^2 Libræ on the 10th of August, at nineteen minutes past two P.M., the star 1° 58′ north. On the 16th of September, at fifty-three minutes past three in the morning, the star *g* Ophiuchi will be in conjunction at the distance of only 1′ to the south; so that the two bodies will seem almost to touch each other. On the 27th of September, about six o'clock in the evening, this planet will be in conjunction with Jupiter, when Mars will appear 2° 4′ to the south of Jupiter. On the 4th of October, at thirty-five minutes past ten P.M., it will be in conjunction with θ Ophiuchi, when the star will appear only 6′ south of the planet. On December 18th it will be conjunction with ι Capricorni, at 8^h 47′ P.M., when the star will be only eight minutes of a degree south of Mars.

4. *Vesta, Juno, Ceres, and Pallas.*

These planets will all be in opposition to the sun this year. *Vesta* will be in opposition on the 22d of October, at twenty-one minutes past three in the morning. It will transit the meridian about midnight, at an altitude of 38° 20′. Right ascension 2^h 2′ 27″, north declination 20′ 23″. On the 20th of April, at 1^h 25′ P.M., it is in conjunction with the star *p* Piscium, the star 1° 34′ north of the planet. On the 22d of April, at 10^h 56′ A.M., it is in conjunction with *r* Piscium, the star 1° 11′ south of Vesta. On the 24th of August, at

1^h 44′ A.M., the star ν Ceti will be in conjunction, the star 14′ north of Vesta; both these bodies will therefore be seen in the same field of a telescope.

Juno will be in opposition on the 19th of March, at 2^h 45′ P.M., and will come to the meridian about midnight, at an altitude of about 41° 3′. Right ascension 11^h 59′ 55″, north declination 3° 3′ 15″. Juno will be in conjunction with η Virginis on the 4th of March, at 3^h 24′ P.M., the star 28′ south of Juno. On the 25th of April, at noon, it will be in conjunction with ν Virginis, when the star will be only 7′ north of the planet. This conjunction will afford a favourable opportunity for detecting Juno. On the 24th of May, at 7^h 12′ A.M., it will again be in conjunction with ν Virginis, when the star will be 36′ south of the planet. On the 22d of June, at 8^h 36′ A.M., it will be in conjunction with π Virginis, the star 45′ north of the planet.

Pallas is in opposition to the sun on the 4th of September, at 5^h 34′ P.M., when it will come to the meridian at an altitude of 40° 41½′. Right ascension 22^h 37′, north declination 2° 41′ 20″. Pallas will be in conjunction with the star η Aquarii on the 20th of September, about one in the morning, when the star will be 22′ south of Pallas.

Ceres is in opposition on October 13th, at twenty-two minutes past eleven A.M., and comes to the meridian at that time at an elevation above the southern horizon of 32° 45½′. Right ascension 1^h 35′ 20″, north declination 5° 14′ 30″.

5. *Jupiter*.

This planet passed its conjunction with the sun on the 21st of November, 1840, and will appear as a *morning* star during the months of January, February, March, and April. On the 1st of January it will rise near the south, at thirty-four minutes past five in the morning, and will pass the meridian at forty minutes past nine, at an altitude of nearly 17°. On the 1st of February it will rise in the same quarter, at fifty-six minutes past three, and come to the meridian about eight. On the 1st of March it will rise at twenty-two minutes past two in the morning, and pass the meridian at twenty-eight minutes past six. On the 1st of April it rises at twenty-eight minutes past twelve, midnight; and on the 1st of May at thirty-two minutes past ten in the evening; after which it will continue to be seen in the evening till about the middle

of November. It will be in conjunction with the sun on the morning of the 23d of December, after which it will be a morning star. The declination of Jupiter on January 1st is 21° 3½′ *south*, and on the 1st of December, 23° 13½′ south. On account, therefore, of its great southern declination, its altitude will be low, and its duration above the horizon comparatively short. Its altitude, when passing the meridian about the beginning of December, is only 14° 46′. Its opposition to the sun happens on the 5th of June, at 10^h 16′ P.M. It will appear chiefly in a southerly and southwesterly direction in the evenings of July, August, and September. The best time for telescopic observations on this planet in the evening will be from April till the end of August.

On the 20th of April, at a quarter past three in the morning, all the satellites of Jupiter will appear on the west side of the planet, when viewed with a telescope having an erect eyepiece, and *in the order of their distances from Jupiter*. The same phenomenon will happen on the 8th of June, at thirty minutes past eleven in the evening. On the 5th and 18th of July (on the *east* of Jupiter), at forty-five minutes past nine in the evening; on the 27th of September, at 7^h 30′ P.M.; and on the 17th of November, at 5^h P.M.

6. *Saturn.*

This planet will be seen only in the morning from the beginning of January till the beginning of May. On the 1st of February it will rise at 5^h 8′ A.M., in a direction nearly southeast, and will come to the meridian at 9^h 8′ A.M., at an altitude of 15° 35′; on the 1st of March it rises at twenty-eight minutes past three in the morning; on the 1st of April at thirty-one minutes past one; and on the 1st of May at thirty-two minutes past eleven in the evening. From January till May the planet will be seen chiefly in a *southeasterly* direction in the morning, at a small elevation above the horizon. From July till October it will be seen in the evening, chiefly in a southerly and south-by-west direction. It is in opposition to the sun on the 21st of June, when it rises about eight in the evening, and passes the meridian about midnight. It will be in conjunction with the sun on the 27th of December. Its right ascension on the 1st of January is 17^h 43′, and its south declination 22° 21′. On the 31st of December its right ascension is 18^h 26′, and south declination 22° 40′. On ac-

count of its great southern declination and its vicinity to the sun, it will not be much noticed during the latter part of October and the months of November and December.

During this year the ring of Saturn will be in a very favourable position for telescopic observation, the elliptical figure of the ring appearing nearly at its utmost width, so that it will appear very nearly to encompass the planet. The best periods for telescopic observations in the evening will be from the month of May till the end of September.

7. *Uranus.*

Uranus will be in opposition to the sun on the 15th of September, at 10^h 17′ A.M., when it will pass the meridian about midnight, at an altitude of 34° 15′. Right ascension at this period, 23$_h$ 33½′; south declination, 3° 45′. It is in conjunction with Venus on the 25th of January, at twenty-five minutes past one in the morning, and is distant from Venus only four minutes of a degree. It is in conjunction with Vesta on the 9th of April, at nine in the evening, being 3° 54′ to the north of Vesta. On the 1st of September it passes the meridian at fifty-one minutes past twelve, midnight; on the 1st of October, at forty-nine minutes past ten in the evening; on the 1st of November, at forty-three minutes past eight; on the 1st of December, at forty-four minutes past six; and on the 1st of January, 1842, at forty-four minutes past four in the afternoon. The most eligible periods for detecting this planet by means of the telescope are the months of August, September, October, and November.

N.B. The preceding descriptions of planetary phenomena are chiefly intended to inform common observers as to the seasons of the year when the different planets may be seen, and the quarters of the heavens to which they are to direct their attention in order to distinguish them. It may be proper to observe, that the planets in general cannot be distinguished by the naked eye for about a month before and after their conjunctions with the sun, except *Venus*, which may frequently be seen within a week before and after its *inferior* conjunction; but this planet will sometimes be invisible to the naked eye for a month or two before and after its *superior* conjunction with the sun.

For a particular description of the motions, distances, mag-

nitudes, and other phenomena in relation to the primary planets and their satellites, the reader is respectfully referred to the volume entitled "CELESTIAL SCENERY; or, the Wonders of the Planetary System displayed," where all the most interesting facts connected with the solar system, and the scenery it displays, are particularly detailed.

ECLIPSES AND OCCULTATIONS.

ECLIPSES IN 1840.

There will be four eclipses this year, two of the sun and two of the moon; but none of them will be visible within the limits of the British isles, nor in the United States of America, except a partial eclipse of the moon, August 13th, at 7^h 23′ A.M., Greenwich time. This eclipse will be visible at Philadelphia, New-York, Boston, and most parts of North America, but not in Britain. On March 4th there will be an *annular* eclipse of the sun, the middle of which will happen at 7^h 23′ A.M.; and on August 27th there will be a total eclipse of the sun; middle of the eclipse about 7^h A.M. These two interesting eclipses will be visible chiefly in the eastern parts of the globe, in the eastern parts of Africa, the East Indies, the Indian Ocean, Australia, &c. At the Cape of Good Hope there will be a *partial* eclipse of the sun on August 27th; but both eclipses will be invisible both in Britain and America.

ECLIPSES IN 1841.

This year there will be six eclipses, four of the *sun* and two of the *moon*, at the following times: Of the *sun*, January 22d, at 5^h 23′, a partial eclipse, visible only in a small portion of the Southern Ocean: of the *moon*, February 6th, at 2^h 6′ A.M., visible in Great Britain; of the *sun*, a partial eclipse, February 21st, at 11^h 4′ A.M., visible chiefly in the North Atlantic Ocean, Iceland, and East Greenland; of the *sun*, a partial eclipse, July 18th, at 2^h 24′ P.M., visible in Baffin's Bay, Iceland, Norway, Sweden, Russia in Europe, Prussia, Germany, Scotland, &c., but invisible at Greenwich; of the *moon*, a *total* eclipse, August 2d, at 10^h 1′ A.M.; of the *sun*,

a partial eclipse, August 16th, at 9ʰ 19′ P.M., visible chiefly in the South Pacific Ocean. The times here specified denote the *middle* of the eclipse.

All the above eclipses are invisible at Greenwich, and in most parts of Britain, except the total eclipse of the moon on February 5th and 6th, of which the following is a more particular detail in mean time at Greenwich :

		h m.	
First contact with penumbra of the earth's shadow, February 5th		11 24	P.M.
First contact with dark shadow, February 6th		0 20	A.M.
First total immersion in dark shadow,	ditto	1 17	A.M.
Middle of the eclipse,	ditto	2 6¼	A.M.
Last total immersion in dark shadow,	ditto	2 55½	A.M.
Last contact with dark shadow,	ditto	3 52¾	A.M.
Last contact with penumbra,	ditto	4 49	A.M.

Digits eclipsed, 20¼.

A large *solar* eclipse will be visible on July 8, 1842 ; and no eclipse of the sun will be visible in Britain till that time. That eclipse will be *total* in the southern parts of France, and large even in and near London. At Greenwich, it will begin at 4ʰ 53½′ A.M., and end at 6ʰ 43′. Digits eclipsed, 9° 42½′. Of course this eclipse will not be visible in the United States, nor throughout any part of America, as the sun will not at that time be risen to those places.

OCCULTATIONS OF VENUS BY THE MOON IN 1841.

On the 26th of March, 1841, the planet Venus will suffer an occultation by the moon. It will begin to be immersed behind the moon at forty minutes past two o'clock in the afternoon, of Greenwich mean time, and will emerge from behind the opposite limb of the moon at twenty-three minutes past 3 P.M. Another occultation of Venus will happen on the 12th of September, 1841 ; immersion thirty minutes past six in the morning, emersion forty-two minutes past 7 A.M. In the occultation of March 26, Venus will be nearly in the form of a half moon, and the moon in the form of a crescent. Venus will be immerged at the dark (or eastern) limb of the moon, and will emerge from the enlightened crescent. They will be then nearly on the meridian, at an altitude of about 60°, and nearly three hours of right ascension east of the sun. A short time after sunset, Venus will be seen a little west from the lunar crescent, but very near it, shining with considerable splendour. Although this occultation will happen while the

sun is above the horizon, yet both the moon and Venus will be easily perceived with a common telescope of very moderate magnifying power. In the occultation which takes place on the morning of September 12, Venus will, as in the former case, be nearly in the shape of a half moon, and the moon a slender crescent, being only 2½ days from the period of conjunction, or new moon. In this case Venus will be immerged at the enlightened limb of the moon, and emerge from the dark limb. Both bodies will be then in an easterly or northeasterly direction, and the immersion will take place a little after sunrise; about half an hour before which, Venus will be seen a very little to the east of the moon.

EXPLANATIONS OF SOME OF THE ENGRAVINGS OF THE STARS.

Plates I. and II., which represent portions of the heavens as seen about the middle of January and the 1st of September, have been explained p. 21–24; and Plate III., which represents the north circumpolar stars, has been explained p. 25–29.

Plate IV. represents some of the larger stars and principal constellations around the *South Pole*, to the distance of 45° from that pole. It also shows a portion of the Milky Way which traverses that region of the heavens, and which is said to appear there with peculiar brilliancy. One of the principal constellations which is frequently noticed, and which appears peculiarly striking to seafaring people and others, is called *Crux* or the *Cross*, from the resemblance it bears to that figure. It consists of five stars, one of the first magnitude, two of the second, one of the third, and one of the fourth magnitude. Four of these are in the position of a cross; the northernmost and southernmost of which are always in a line with the South Pole, and therefore serve for a direction in south latitude to discover that pole, as the Two Pointers in the Great Bear serve to direct the eye to the *North* Polar-star. There is no large or prominent star at or near the South Pole This constellation is represented near the line, or meridian, which points at XII., opposite to the month

of *May*. All its stars, except the lowermost, appear within the limits of the Milky Way. The stars immediately below the Cross belong to the *Centaur;* those on the left, opposite *April*, belong to *Robur Caroli*, or King Charles's Oak, which contains a star of the first magnitude. Farther to the left, opposite *March*, is *Argo Navis*, or the *Ship*. Still farther to the left, opposite *February*, is *Pisces Volans*, the Flying Fish, which contains a star of the first magnitude, named *Canopus*. This star is marked near the left side of the map, opposite the middle of February. To the *right* from the Cross are the two forelegs of the Centaur, distinguished by two stars of the first magnitude, named *Agena* and *Bungula*, Agena being the one next to the Cross. They are in the Milky Way, and appear opposite the month of *June*. Next to the Cross and the Centaur, on the right, are *Circinus*, or the Compasses; the Southern *Triangle*, which contains three stars of the second magnitude in the form of a triangle; and *Ara*, or the Altar, which lies adjacent to the right-hand side of the map, opposite the space between *July* and *August*.

Directing our attention to the upper part of the map on the left, there is the constellation *Equuleus Pictoria*, or the Painter's Easel, which consists of a number of small stars. Next to this, and a little above it, is *Dorado*, or the Sword Fish, which contains two or three stars of the second and third magnitudes. To the right of Dorado is *Hydrus*, or the Water Snake; above which is *Achernar*, a star of the first magnitude in *Eridanus*, which appears opposite the 1st of *December*. Next to Achernar, on the right, is *Toucana*, or the American Goose; above which, opposite *November*, is the *Phœnix;* to the right of which is the *Crane*, which contains two stars of the second magnitude; below which is *Pavo*, or the Peacock, which contains several stars of the second and third magnitudes; below Pavo, opposite to August, is *Telescopium*, or the Telescope, which contains no remarkable stars. Within eleven degrees of the South Pole, represented by the central point of the map, are two of those whitish or nebulous spaces called the *Magellanic Clouds*, which are found by the telescope to consist of small stars and nebulous appearances. The other Magellanic cloud, which is the largest, is at a considerable distance from the South Pole. In specifying the names of some of the above-stated constellations, the *incongruity* of the animals and figures by which these groups of stars are represented will at once be apparent to the reader.

Fig. 85.


Right 54° Ascension
Magnitudes
3 5 6 7 8 9
24°
North Declination
North Declination
23°
55°
Right Ascension
THE PRINCIPAL STARS COMPOSING
THE PLEIADES

PLATE V. contains a condensed representation of some of the principal constellations in the northern and southern hemispheres on *Mercator's Projection*, chiefly for the purpose of exhibiting THE COURSE OF THE MILKY WAY, and the relative positions of the constellations. Some of the larger stars may be here traced, as α Lyræ, Capella, &c., but they are more easily distinguished in the other maps. (See the description given of the course of the Milky Way, p. 144.)

Fig. 80 (p. 340) represents the comet of 1661, as seen by Hevelius; the atmosphere, or nebulosity surrounding the nucleus, when viewed at different times, varied in its extent, as likewise the tail in its length and breadth.

Fig. 81 (p. 340) represents a class of comets which have their tails somewhat bent, which some suppose to be owing to the resistance of the ethereal fluid through which they move.

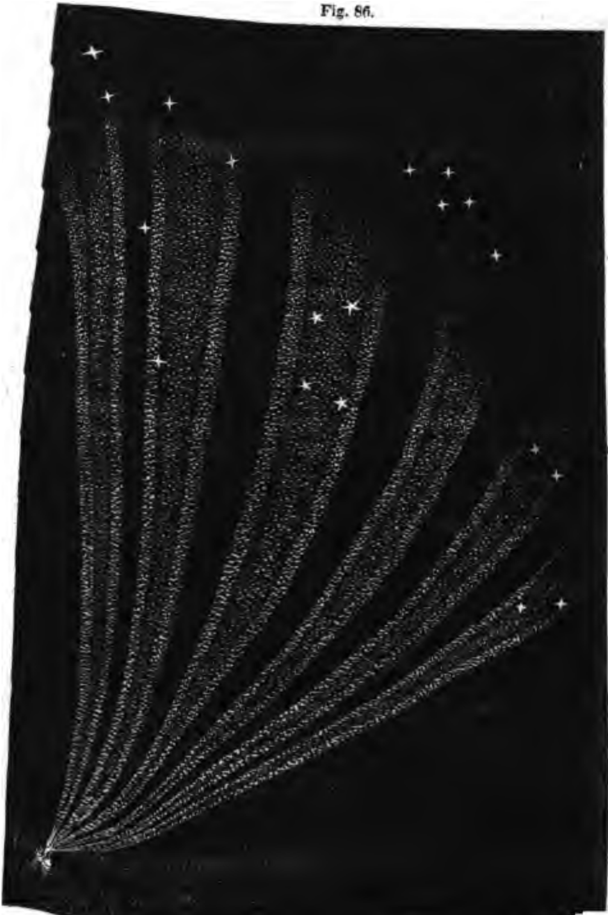
Fig. 85 represents a telescopic view of the *Pleiades*, a group of stars in the constellation Taurus. About forty stars are here represented, but with powerful telescopes many more may be discovered. *Rheita* affirms that he counted 200 stars within this cluster, and yet telescopes, at the period when he lived, had not arrived at the point of perfection they have now attained. The principal star in the Pleiades is *Alcione*, of the third magnitude, which is here represented near the centre of the cluster. The names of the others visible to the naked eye are Merope, Maia, Electra, Tayeta, Sterope, and Celino. Merope is the one which some suppose to have been lost. In fabulous history these stars were the seven daughters of Atlas and the nymph Pleione, who were turned into stars, with their sisters the Hyades, on account of their mutual affection and amiable virtues.

The other five stars, besides Alcione, are of the fifth magnitude, as represented in the plate; and the rest are telescopic stars of the sixth, seventh, eighth, and ninth magnitudes. The lines from right to left are portions of circles of declination, which run parallel with the equinoctial, as the parallels of latitude on the terrestrial globe do with respect to the equator; and on these the *declination*, or distance of the body from the equinoctial, is marked. The other lines, from top to bottom, are portions of circles of right ascension corresponding with meridians on the terrestrial globe. On these are marked the right ascensions of the heavenly bodies or their distance, reckoned on the equinoctial from the first point of Aries.

One of these lines, at the top and bottom, is marked 54° showing that the stars in that line are 54° east from the first point of Aries; and the number 23, marked at the right and left hand sides, shows that the star or stars in that line are 23° north of the equinoctial.

Fig. 86 represents the tail of the splendid comet of 1744 which was divided into six branches, as described p. 349. See also the description given of this comet, p. 132, 133.

Fig. 86.



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THE END.

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